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Eucalypts in Argentina 119
C. Sibley Elliot

Social and Private Costs and Benefits in Forestry 124
A. C. Worrall

Forest Tree Breeding Research 129
F. Mergen

Equipment for Pest and Disease Control 138
S. F. Potts

Forest Industries Planning in Indonesia 155
J. A. von Monroy

The Work of FAO
European Forestry Commission 160
Technical Assistance Reports 160
A Forestry Program for Africa 161

Equipment Section 162

News of the World 165

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FAO — The Food and Agriculture Organization of the United Nations — grew out of a United Nations Conference held at Hot Springs, Virginia, U.S.A., in May 1943. The nations agreed to work together to secure a lasting peace through freedom from want. The Organization was formally founded at Quebec, Canada, in October 1945. It was located at Washington D.C. until 1951 when the Headquarters office was moved to Rome.

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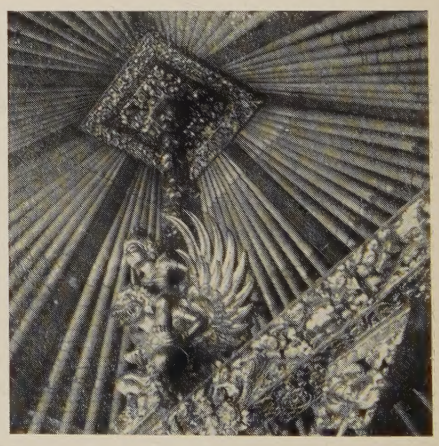

Cover Photograph. *A well-designed vaulted ceiling of bamboo in a temple in Bali. Bamboo constitutes the most important building material in Indonesia, and research is being concentrated on improving its durability and uses, instead of seeking substitutes for this fine and versatile material.*

Unasylva

An International Review of Forestry and Forest Products

PROBLEMS IN TECHNICAL ASSISTANCE

TECHNICAL assistance means the sharing of skills and knowledge among nations so as to promote the economic and social development of the less developed countries. It is an appealing idea. More than that, it is a going concern, and the new United Nations Special Fund for Economic Development is going to expand it further.

But every now and again a story appears about the misuse of technical assistance or the failure of a project, on the basis of which the sceptics then eagerly pass judgment on the whole program. Perhaps those who write about technical assistance are partly to blame for this. They believe in it and report on its successes but rarely mention its difficulties.

Like any great undertaking, running a technical assistance program is complex and obstacle-ridden. It speaks well for the general soundness of projects and the efficiency and devotion of the specialists in the field that most projects go through as planned and many produce results which exceed expectations.

The expert himself has to be much more than a package of modern knowledge and techniques. To be effective, he must bring to his job not only a desire to understand the technical problems but also a desire to understand the people with whom he is going to be facing the problems. Sometimes technicians from the advanced countries expect too much to apply their own high level approach to local development. They do not always realize that the " latest " techniques are not necessarily the best for an economically underdeveloped country.

It would require acute perception to tell in advance if an expert is going to have all the proper qualities with which to make a success of his assignment. Sometimes, also, a field officer finds that the job he is actually called upon to do requires different technical qualifications than those which he possesses. This is not his fault.

Because of the diversity of nationalities available to the United Nations service, the language problem is perhaps less acute than with bilateral technical assistance. But even with the world-wide facilities at its command, FAO is not always readily able to find the necessary speciality *and* the right language in the same person. Sometimes the language handicap can be overcome if the expert works at an urban center, if he is able to work through a national counterpart, or if he is particularly resourceful in making himself understood. If the handicap cannot be overcome, the project is doomed.

When one thinks of all the factors to be considered, it is not surprising that it may take months to find the right man to fill a particular request. But time is also a factor, and a brilliant selection may count for nothing if an expert arrives too late to do the job required of him, or if his permanent employer will not release him for the period really required.

Like many other activities, technical assistance sometimes suffers from the tendency to believe one's own field of interest to be more important than that of anyone else. Ministers, often changing, sometimes will not accord the priority being sought. Projects may then be unsuccessful, directly or indirectly, because of inadequate funds: inadequate to provide a mission with the supplies it needs, inadequate to carry out the project on the scale initially conceived, inadequate to follow up reports and recommendations.

Capital funds do not substitute for the human skills which technical aid can provide but the reverse is equally true. Once people have been taught skills, they are eager to use them. If there is no money to expand the industry or service for which they have been trained or to plant the forests which they have been taught how to establish, it can only lead to disillusionment. The majority of projects are conceived within the framework of larger national development plans, as well they should be, but are dependent on yearly financing. Plans become modified and the fact that an allocation is made one year, for instance, toward creating a demonstration center, does not guarantee that next year the same government, or a new one, will appropriate money to expand its facilities as planned.

Successful technical assistance often resolves itself into an exercise in patience. Certainly all the difficulties met with do not doom this venture in economic development. Far from it. They simply mean that it may take longer than the uninitiated might expect to achieve the desired results.

FIGURE 1. – *Typical* E. globulus *logs and trees in a 40-year-old, wide shelter belt. Mar del Plata, Province of Buenos Aires.*

FIGURE 2. – *Typical tree of* E. globulus *felled in an 80-year-old, wide shelter belt. Mar del Plata, Province of Buenos Aires.*

Eucalypts in Argentina

C. Sibley Elliot[1]
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Eucalypts were introduced into Argentina a little more than 100 years ago, and the experiment was so successful that the practice of planting them to provide shelter on the windswept plains of the Pampa became widespread. Today, these otherwise almost treeless plains are dotted with clumps and belts of eucalypts, some of them up to 80 years old, with trees up to about 50 meters high and of butt diameter up to about 1 meter. The principal species in these shelterbelts are *Eucalyptus globulus*, *E. viminalis* and *E. rostrata* (*camaldulensis*).

Some 10 or 11 years ago recognition of the possibility of eucalypts playing an important part in meeting Argentina's shortage of home-grown timber led to the beginning of extensive planting of the above and other species of eucalypts in widely different parts of the country. In some instances, these plantations have been and are being established by government bodies such as the railways administration and provincial forestry administrations. In many others, they represent private investment ranging from substantial progressive annual plantings by *estancia* owners to small scale plantings by individuals who have acquired land specially for the purpose. In other cases, forestry companies have been formed and through these many people of limited means have invested their savings in eucalypts.

As would be expected, there have been some failures in experimental plantings under varied conditions of soil and climate, but these have been much more than balanced by the phenomenal growth obtained when species suited to a particular locality have been planted. Those who have invested their money in eucalypts see in this rapid growth a promise of the early returns that every investor wants. Most of them are thinking only in terms of small round posts and poles, for which there is a very big demand in Argentina and for which small to relatively small trees can be used provided satisfactory preservative practice is adopted. Important as is the building up of the country's supply of home grown posts and poles, it is not necessarily the summit of the contribution that locally grown eucalypts can make towards meeting Argentina's timber needs, and the national and provincial forestry administrations have had in mind a much wider utilization.

The suitability of many eucalypts for a wide range of high quality uses requiring sawn timber has been established in Australia. So also has the high degree of resistance to decay of some species. Nevertheless, officers of the abovementioned administrations have been concerned as to whether the rapid growth of the trees in Argentina would result in sufficient changes in the properties of the timbers to reduce their usefulness. As long ago as April 1957, Jose C. Tinto (Officer-in-Charge, Department of Dendrology, National Administration of Forests, Argentina), writing in *El Forestal*, recorded that eucalypts were being used in Argentina for posts and fence strainers, parquet flooring, fruit cases and furniture, as well as for veneer, hardboard and paper pulp. Apart from parquet flooring, however, use in the form of sawn timber was and still is limited to isolated instances. Moreover, it was not known whether or not the difficulties being encountered in the conversion of the timber were of the same order as those that had been experienced in Australia.

Because of this, the Government of Argentina requested, under the Expanded Technical Assistance Program, the services of someone familiar with the utilization and treatment of eucalypt timbers. The task was to assess the usefulness of the timber that would soon be available from plantations throughout the country, and to advise on its sawing, preservative treatment and seasoning. The questions of paper making and manufacture of hardboard, veneer and plywood were not included. It was the privilege of the writer to spend almost three months (August-October, 1958) in Argentina on this assignment, working in close collaboration with officers of the National Administration of Forests.

On the advice of that administration, work and observations were concentrated in the Greater Buenos Aires area and in the Provinces of Buenos Aires, Mendoza and Entre Rios. This covered the major activities in the preservative treatment of eucalypt poles and posts and the conversion of eucalypt logs to sawn timber. It also covered, insofar as *E. globulus*, *E. viminalis* and *E. rostrata* were concerned, trees ranging from young plantation trees to relatively old estancia shelterbelt trees comparable in size and form with eucalypts commonly sawn in Australia. Observations on the only other species studied, *E. saligna*, were more limited and did not include trees more than 20 years of age.

Observation of the general properties of the timber obtained from the older trees provided a valuable basis on which to assess the usefulness of the timber that will become available from the many young plantations now established if the trees are allowed to grow beyond pole size.

[1] On loan to FAO as Technical Assistance Officer.

FIGURE 3. – *Truck load of typical* E. globulus *logs from an 80-year-old, wide shelter belt. Mar del Plata. Province of Buenos Aires.*

PROPERTIES AND BEHAVIOR OF TIMBER

Density

There seems to be no doubt that the timber of eucalypts grown in Argentina is somewhat less dense than that of the same species grown in Australia, and the red-colored timbers tend to be somewhat lighter in shade. The difference in density is not as great as was expected, however. Values obtained by the National Administration of Forests show the average basic density of *E. globulus,* for example, to fall just above the lower limit of the range of that species in Australia. To supplement such work as has been done there is need for a systematic study of the physical and mechanical properties of all the eucalypts being grown in the country, material from as wide an age range as possible being included in the investigation.

Width of sapwood

With a few exceptions, the thickness of sapwood in young, quickly grown trees was not as great as was expected. However, exceptionally wide sapwood was sometimes observed in logs as much as 80 centimeters in diameter, and it may be necessary to include sapwood in timber sawn from such logs and from small diameter logs. As the Lyctus borer is prevalent in Argentina, it will probably be necessary to treat the timber of Lyctus susceptible species if much sapwood is included.

Growth stresses and " spring "

As in Australia, small logs were found to " spring " considerably when sawn longitudinally, because of the presence of growth stresses. It was possible to demonstrate, however, that, by adopting a suitable breaking down pattern, " spring " could be reduced to a minimum. Again as in Australia, larger logs did not give trouble in this way.

In only a small proportion of the many logs inspected were the growth stresses sufficient to cause popping of the ends as soon as the trees were felled or the logs cross-sawn. The frequency was of much the same order as in Australia.

Checking and end-splitting due to drying

End checking and splitting of the ends of logs while waiting to be sawn, and of posts and poles while being dried prior to preservative treatment, also appeared to be of much the same order as in Australia in trees of comparable size, and less serious than it is reported to be in South Africa. These observations were made in late winter and spring, and more trouble would be expected (and was in fact reported) in logs cut in the summer.

Wastage through end checking and splitting could be reduced by adopting the following established practices:

(*a*) applying a suitable end-coating to the butts of trees as soon as they are felled, and to fresh ends of logs as soon as they are cross-sawn;

(*b*) sawing logs as soon as practicable after felling;

(*c*) leaving logs in as long lengths as practicable until they are sawn.

Most eucalypts have a strong tendency to check on the wide faces of tangentially sawn boards and planks, and the behavior of the Argentine-grown eucalypts was found to be no worse in this regard than that of the same species in Australia. Because of this tendency, quartersawing of eucalypts is always recommended, and it was being practiced reasonably well in Argentina.

Collapse

Collapse was observed commonly in *E. globulus* and was of about the same severity as is usual in Australia. Experiments with a few specimens taken at random showed that, in most cases, good recovery could be obtained with the simple standard reconditioning treatment, which should undoubtedly be adopted. Apart from the fact that it gives fuller sized boards, it results in less movement of the finished board with change in atmospheric conditions. Specimens that did not respond to this treatment were found to contain tension wood, which appeared to be present in a good many logs of this species. Little obvious collapse was observed in *E. rostrata*, but it is a feature of this timber in Australia that sufficient collapse to justify reconditioning can be present without being noticeable, and it may be found that in Argentina, also, its treatment would result in fuller sized boards.

Warping

Severe sloping grain in the vicinity of branches was common especially in *E. globulus* and *E. rostrata*, and gave rise to serious localized distortion, especially when shrinkage was increased by collapse. This problem should be less when normal plantations, yielding trees with fewer branches, are drawn on.

As in Australia, an appreciable proportion of trees of *E. rostrata* had somewhat crooked boles, even when grown in plantations. The accompanying sloping grain is responsible for a tendency to warp, as is spiral grain, which was found to be very common in *E. globulus*.

There was found to be a need for wider application of special stacking precautions to reduce warping of boards containing sloping or spiral grain.

Unfortunately, because spiral grain is so common in *E. globulus* and causes poles to " wind " sufficiently to break telephone wires, the national telecommunications authority will no longer accept poles of this species.

Kino

All the timber examined was much freer from kino veins and pockets than is the average sample of eucalypt timber in Australia.

Usefulness as Sawn Timber

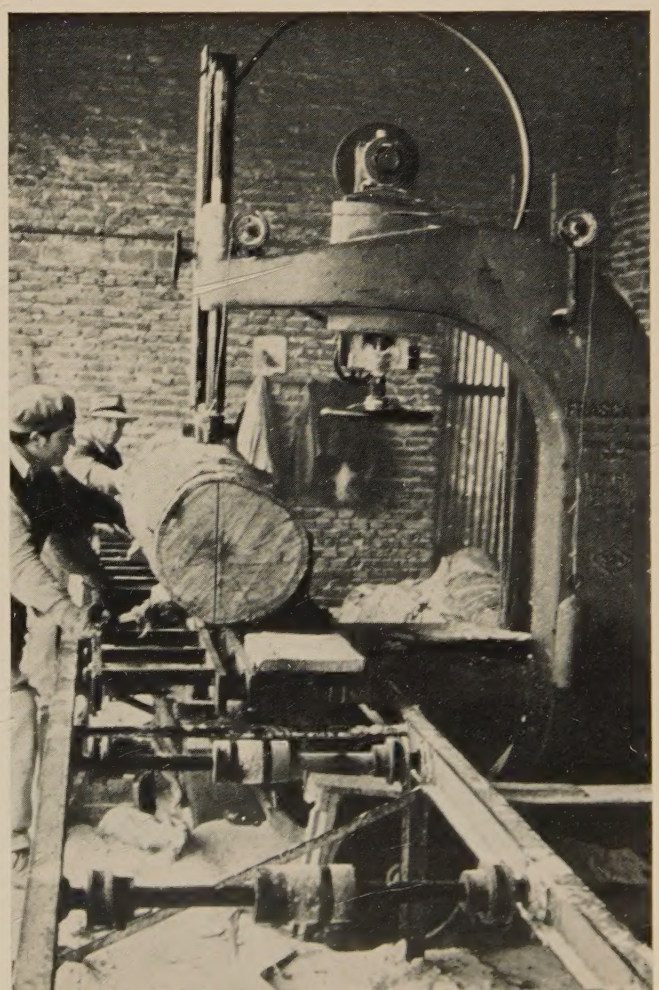
The judgment reached was that the timber of the four species observed, even when sawn from comparatively young trees, had suitable properties for a wide range of uses such as furniture, joinery, flooring, house construction and case making. Little was actually being used for any of these purposes except flooring, but the few craftsmen who had made furniture from *E. rostrata* and *E. saligna* in various parts of the country were enthusiastic about the good hand working properties of these timbers.

A considerable quantity of high grade parquetry flooring was already being made. Because of the prevailing demand for " blonde " floorings, *E. globulus* and *E. viminalis* were found to be more popular than the other species which would make equally good flooring. There was a common wastage of 30 percent to 40 percent of the dried narrow boards from which parquet blocks were cut. The two main causes were local distortion due to severe sloping grain in the vicinity of branches, and collapse, the latter increasing the severity of the former. The usual practice was to dock out the warped and undersized portions, and discard them. There is no doubt that adoption of the reconditioning treatment would reduce the wastage appreciably and a further saving could probably be obtained by using any docked portions for other purposes in which short lengths could be utilized. The parquet blocks are cut from short (approximately 2 meters) narrow boards, and in one plant any of these that contained warped areas were removed from the parquetry stock and used for making cases for machinery, etc.

Excellent, though isolated, examples of the use of these four species for the other purposes listed were seen, and there is no doubt that some of the other species being grown could be put to similar uses.

One small timber house built completely of *E. rostrata* had been built for approximately one year and no fault of any kind was evident. Provided the joinery, flooring, lining and sheathing were properly seasoned, eucalypt

Figure 4. – *Typical saw and log carriage used for eucalypt logs.*



timbers could be used with satisfaction for small timber prefabricated houses such as those being erected in some parts of the country. One very good example of the use of *E. globulus* for roof framing timbers was seen in a house built in 1943.

The builder of the *E. rostrata* house is a manufacturer of furniture, doors, etc., and this species comprises between 70 percent and 80 percent of the timber he uses.

Attempts to make citrus cases from green *E. saligna* cut from trees about 5 years old had not been successful owing to collapse and splitting at the nails. On the other hand, excellent sample export citrus cases had been made from air-dried *E. saligna* cut from a tree 20 years old, with a diameter of about 50 centimeters. Also, a very high quality office desk seen had been made from air-dried *E. saligna* said to have been cut from a tree 10 years old and about 20 to 30 centimeters in diameter.

Durability Considerations

Poles and posts

It was found that naturally durable species of eucalypts such as *E. sideroxylon* were being planted in the hope that, because they were used untreated as poles in Australia, they could also be used untreated in Argentina.

There is strong evidence that the resistance to decay shown by the durable eucalypts increases with the age of the tree and it is not likely that the quickly grown trees of those species which have a reputation for natural durability in Australia will have attained full durability by the time they reach pole size in Argentina. Moreover, the central core of eucalypts is notably nonresistant to fungal attack and, in the relatively small diameter poles common in Argentina, the central core of 5 centimeters to 7 centimeters, plus the sapwood, constitutes a big proportion of the pole. This means that, even if the rest of the heartwood has attained good durability, it makes up a comparatively thin annulus enclosing and surrounded by nondurable wood.

Because of this, it is considered that preservative treatment of poles and round fence posts is probably essential for all eucalypts in Argentina. However, it was recommended that poles of species such as *E. sideroxylon* should be tested for natural durability by erecting them in nonservice lines.

As the high pressure (approximately 70 atmospheres) preservative treatment necessary for impregnating the heartwood of eucalypts would be uneconomic for fence posts, and as the heartwood of relatively small trees of any of the eucalypts is not likely to be decay resistant, split fence posts obtained from relatively small trees could not be expected to be successful. The treatment of the sapwood of poles and round fence posts as practiced in Australia, however, will give good serviceable life, and does not require abnormally high pressures. Actually, the pressure used for poles in Australia is about 13 atmospheres and for treating eucalypt poles it may be desirable for Argentina to change from the pressure of about 7 or 8 atmospheres being used for poles of other timbers. For small round fence posts lower pressure plants, such as those developed in Australia, and sap replacement treatment using suitable waterborne preservatives that fix in the timber have been recommended.

Figure 5. – E. rostrata *log approximately 80 centimeters diameter, showing exceptionally wide sapwood. Butt log of tree was 1.20 meters in diameter and tree between 40 and 60 years old. San Pedro, Province of Buenos Aires.*

Sawn timber

Perhaps Argentina's greatest need in the way of durable sawn timbers is for railway sleepers. Although it is not one of the most durable eucalypts, the railways administration had hopes that this need might be met, at least to some extent, by *E. globulus*, which was available in reasonable quantity in shelterbelts 40 years or more old in the central latitudes of the country, where the main sleeper requirements are, and which are remote from the northern native timbers.

A large trial parcel of *E. globulus* sleepers had been cut from trees about 40 years old, and inspection showed that many of these contained a large proportion of nonresistant core and/or sapwood and had bad ring shakes and other defects. It was obvious that bigger trees would have to be cut to provide sound sleepers. Even then, on the basis of Australian experience, the species could not be expected to yield really first class sleepers without preservative treatment at the high pressure to which reference has already been made. In view of the reported availability of adequate though distant supplies of white quebracho, an easily treated timber, it was considered that installation of high pressure plant to treat *E. globulus* would not be justified.

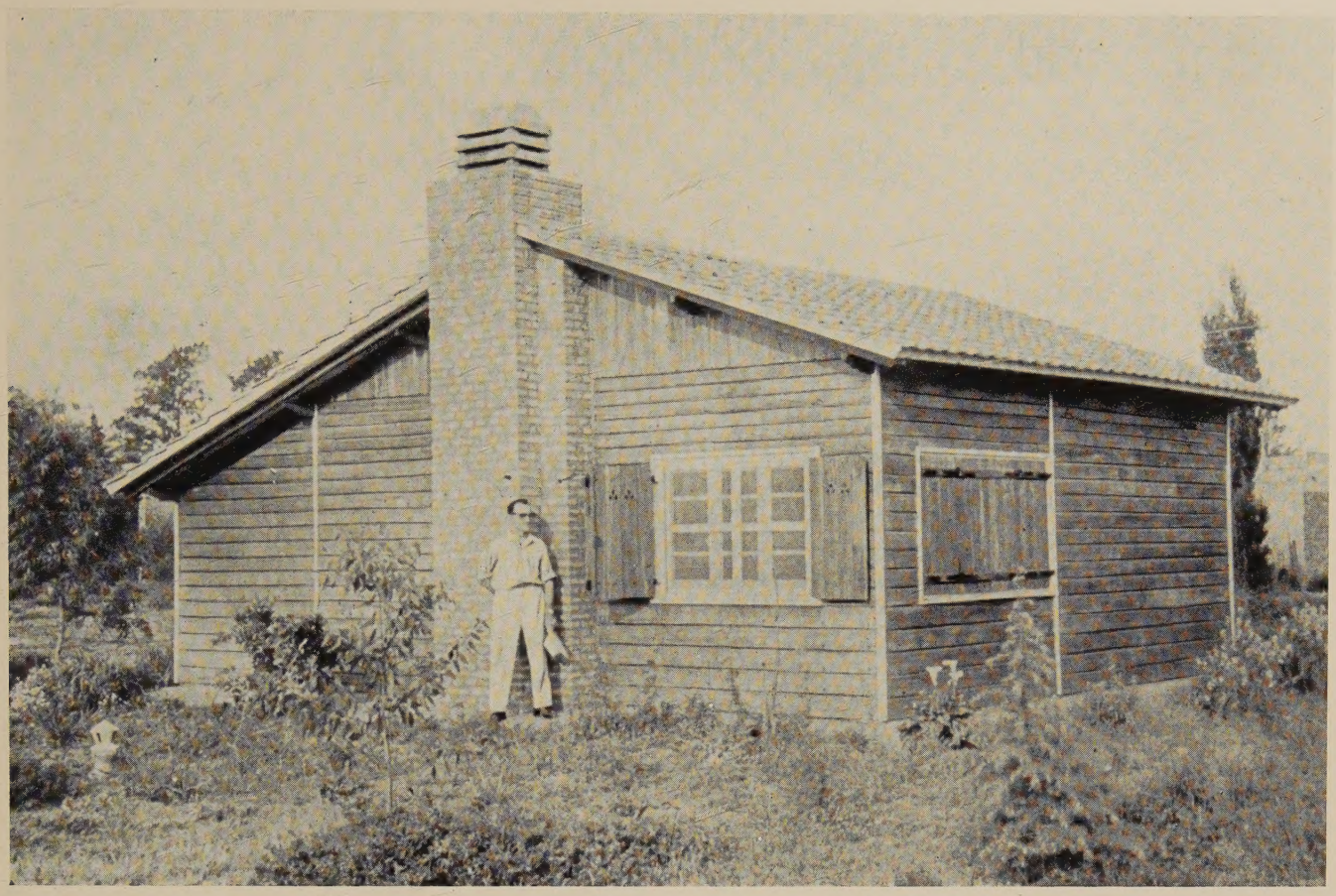


FIGURE 6. – *Precut timber house built entirely of* E. rostrata. *San Pedro, Province of Buenos Aires.*

This does not rule out the possibility of *E. globulus* of adequate age being a valuable source of durable timber for somewhat less exacting uses, or of other naturally more durable eucalypts which are growing well in parts of the country eventually becoming an important source of durable timber for railway sleepers and other uses. The need is to determine at which age the various species will reach maximum durability.

In this respect, it was observed that *E. globulus* poles not in contact with the ground and probably cut from trees about 10 to 15 years of age, had decayed completely in 8 years, whereas under similar climatic conditions a 60- to 70-year-old tree of the same species had been on the ground for about the same time and was still perfectly sound.

There is a good variety of naturally durable eucalypts up to 60 or 70 years of age available in sufficient quantity for experimental purposes, and it is hoped that a systematic investigation of the decay resistance of these species at various ages will be commenced in the near future. Specimens from mature trees grown in Australia have been offered for comparison. Laboratory soil jar tests could produce, in a relatively short time, information of great value in deciding the minimum age at which to harvest plantations of the species being grown to produce durable timbers.

CONCLUSION

It is probable that the main problems to be faced in developing the wide and wiser use of eucalypt timbers in Argentina is to encourage growers and manufacturers and the public to appreciate the value of some species for high quality use and for a variety of other uses as widely different as cases and general building timbers. Growers will have to be convinced that the increased value of the timber will justify allowing some trees to grow to a greater age than that at which they now anticipate cutting them.

In several plantations there was evidence that there would often be an advantage in early thinning. It appeared that not only do many suppressed or subdominant trees virtually stop growing but that, when not removed, they reduce the rate of growth of other trees. Thorough investigation of this possibility and of means of making profitable use of thinnings is very desirable. It appeared that there were rather unique opportunities for utilizing thinnings in Argentina, and it is believed that investigation would prove to growers that, in some cases at least, it would pay them not to look to poles as the ultimate product of their plantations. Poles might rather come to be regarded as a third thinning, following previous thinnings for minor uses and for fence posts, with sawn timber as the ultimate objective.

Social and Private Costs and Benefits in Forestry

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This excerpt from Professor Worrell's recent book Economics of American Forestry *is reproduced by permission of the publishers, John Wiley and Sons, Inc., New York. The book is reviewed on page 170.*

No-one is really independent of the society in which he lives. He depends on that society to support him in many ways, to defend him, and in general to guarantee that he can live in a certain manner. What he does affects other people and what they do affects him. Our own society takes the attitude that it is desirable for individuals to be as free as possible in their decisions and actions. But, if each individual does absolutely as he pleases, we cannot live together as a society without continuous and violent conflict. So individual actions are restricted in the interest of group relations.

The social viewpoint differs from the private viewpoint in that it considers the effect of an action on everyone in the society rather than on any one individual. The economic goal of a democratic society may be said to be the maximum satisfaction of the group as a whole. This is a difficult concept because few, if any, events will benefit or hurt everyone in the group to an equal degree. Many happenings will benefit some and hurt others and these individual effects cannot be added in any way to determine the total effect on the group. Still as a nation we do have this concept and if we cannot accurately determine what increases total welfare we can at least try to recognize and allow for things that might decrease welfare.

A second difference is that society takes a much longer view of events than an individual does. Every individual knows that his lifetime is limited and it is difficult for him to be concerned about things far off in the future. To be sure, many people go to considerable pains to provide for their surviving relatives. And some guide many of their actions by the anticipated effect on their children or grandchildren. But, in general, an individual tends to be interested mainly in what will affect him personally. Of course, society does not have an unlimited outlook either — positive time preference exists for a group as well as for an individual. But, since the group perpetuates itself, it is concerned with a considerable period in the future. (A corporation differs from an individual in that its lifetime is not limited and it therefore can take a longer view of things. In this respect it may act more nearly like the social group than like an individual.)

Finally, the ultimate objective of society can probably be stated as " survival ". That is, survival of the social group regardless of what happens to individuals in the group. This is plainly evident during a defensive war but it also shows up in many peacetime actions. Efficiency in resource use may have to take second place to security. And exhaustible resources may be reserved against future emergency needs even though today's individuals might be better off if they could use them.

Society is concerned with a number of things which an individual may ignore in his economic activities. The individual is primarily concerned only with the costs that he must bear himself and with the benefits that he can obtain himself. If he attempts to maximize his own satisfaction through rational resource use, these are the only costs and benefits he will consider. But society is concerned with all costs and benefits regardless of who bears them or to whom they accrue. This means that an attempt by each individual to maximize his own satisfaction may not result in a maximum total satisfaction for society. If every forestry producer uses his resources most efficiently in terms of his own profit, the total result will not necessarily be the most efficient forest-resource use for the country as a whole.

The real problem in efficient resource use is that *all* costs and *all* benefits must be included in the calculations. If all costs and benefits are included, economic analysis will lead to the most efficient pattern of use. Resources will be allocated to different types of production on the basis of their marginal-revenue products. Their use will be intensified to the point where marginal cost equals marginal revenue. The theory of rational resource use will still be valid. The difficulty is in getting all the costs and benefits into the determination. The free working of the price and market system fails to do this satisfactorily.

Social Costs in Forestry

Private costs consist of all the expenditures which must be made by an entrepreneur in the course of production and any losses or damages which he sustains during that production.

Many real costs of production do not fall directly on the entrepreneur. For example, dissatisfactions of doing the work in the productive process are borne by his employees rather than by the entrepreneur himself. But, in order to get these employees to do the work, the entrepreneur has to compensate them for their dissatisfactions by giving them money and perhaps some other forms of remuneration. So the real costs borne directly by the employees are passed on to the entrepreneur and he has to use part of the revenue he receives from his products to pay these costs. Social costs exist in a situation where the entrepreneur cannot easily be held accountable for some of the real costs of production. In this case, part of the cost is paid by other persons but the entrepreneur is able to keep that part of his total revenue which logically should go to compensate these other cost bearers.

Aside from the ethical objection that the revenue is not divided among all who contribute to its production, social costs also seriously affect the efficiency of resource use. As a simple example, suppose a logger has bought some stumpage, is cutting the timber, and is hauling the logs to a sawmill. Part of the haul is over 5 miles of unpaved public highway. During the logging his trucks tear up this section of road very badly. The logger is able to cover all of the other costs and makes a small profit as his own compensation. If the damage to the road is not taken into account this is an economically sound productive operation. But if the logger is forced to maintain the road in good condition during his operations and finally to restore it to the same shape as when he started, this additional cost will make the whole operation unprofitable. Considering *all* costs, it is not economic to log this timber. If the logger is not forced to maintain and repair this road, the cost of the damage done by his trucks falls on the other people who travel the road and on the public as a whole, which through its highway department must repair the damage. Part of the cost of logging the timber is borne by other people who receive none of the revenues from the logs. To the logger himself it appears to be a profitable operation and he will go ahead with it. To society as a whole it is an unprofitable operation and represents a misallocation of resources.

Most social costs that arise in forestry are not as simple as those in the case of the logger and the road. This was a case in which the amount of damage could easily be determined; there was no question of who was responible for it; and he could be forced to assume the total cost of the damage he had done. There are probably many situations like this in forestry. From a logical economic viewpoint they should be eliminated and the total cost of production absorbed by the entrepreneur. More serious are the less obvious and more complex situations which follow.

A clear cut example of social costs is the downstream damages resulting from the use of land in the watersheds of streams. If headwaters forest lands are managed in a way that contributes to floods, the flood damages sustained by all of the affected people are social costs of managing those forest lands. These costs are so complex — and the people who bear them are so numerous and widely scattered — that they can hardly be passed back to the responsible entrepreneurs. Usually a large number of landowners are involved. They do not all operate in the same way and, therefore, are not equally responsible for the damages. In many cases the entrepreneurs are not even aware that they are causing damage.

A more definite situation exists where logging and other forest operations result in an increase in the silt load of streams and the consequent silting up of dams and stream channels. The damage here is more specific and the source of the silt may be identified with some certainty. But even in this case there is no easy way to force the logger or other entrepreneur to assume these costs.

An opposite extreme of indefiniteness exists where the form of silviculture practiced and the type of forest maintained affect the water regimen of streams flowing from a property. The influence may show up in total volume, seasonal distribution, and fluctuations of water flow in the streams. A change in forest management which affects any of these may work a hardship on communities or industries dependent on this water. Such hardships are social costs but they are difficult to measure and they may develop and change over long periods of time. It seems likely that some production costs will always remain social costs no matter how much effort is made to convert them to private costs.

An important social cost in forestry is the depletion or destruction of the future productivity of forest land and growing stock. Both land and growing stock are "flow" resources which can be maintained indefinitely by proper use and management. In extreme situations, both land and growing stock can be destroyed. The private cost to the entrepreneur of such an action is the price he pays for the land. If he paid $100 per acre for land and growing stock and when he is finished using it the land is bare and utterly worthless, he has incurred a cost of $100 for each acre used. The cost to society, however, is the value of all the timber crops which might have grown on that land in the future.

Theoretically, in a perfect market, the $100 price paid for the land would represent a capitalized value of its future productivity. But, in setting a current price the market may underestimate the future productivity of the land. (Most speculation in land assumes such underestimates). And the private market will discount future returns much more heavily than society might. It is probably not correct to say that a cord of wood to be received 100 years from now has the same value to society as a cord of wood to be received today. But this is more nearly true of society than of an individual.

The real extent of this social cost is hard to determine. If a large proportion of our forest land and growing stock were destroyed, there would be a future shortage of all forest products and services. Parts of China and some of the Mediterranean countries where forests were completely eliminated indicate that the long-run cost

to society would be terrific. Because of our tremendous forest resources, the destruction of a limited amount of land probably does not represent a large social cost. If our population continues to grow, however, the pressure on resources may one day reach the point where even a small area of additional forest land would have great value.

The depletion of land and forest resources is not as serious as their destruction because such resources can be rebuilt. Depletion does not represent a permanent total loss to society. But, when land and growing stock are depleted today and must be rebuilt in the future, part of today's costs are being shifted to tomorrow's people. If forest products are made available at today's prices by stripping the timber instead of maintaining the growing stock, future people may have to pay much higher prices for the wood products they can get.

More serious is the fact that the total cost of rebuilding land and growing stock after it has been depleted is greater than the total cost of maintaining the growing stock would be. The amount of money it would have cost the entrepreneurs who cut the white pine forests of Michigan to provide for regeneration and to protect the new stands is insignificant compared to what it has and will cost to re-establish high-quality forests on those lands. Land and growing stock that has been depleted cannot be rebuilt in a short time. It is not like depleting the stock of canned goods in a grocery store, which can be replaced almost immediately by a wholesaler. It is more nearly analogous to draining a large lake which is fed by a spring whose annual flow only slightly exceeds the evaporation from the surface. So long as the lake is full, the spring will keep it full. But if it is emptied it will take many years to refill it. When forest land has been seriously depleted it may take centuries of time and an ecological succession of various kinds of vegetative cover to rebuild its productive potential. The social costs of present forest-depleting practices may fall on a number of future generations of wood users.

The social costs resulting from the depletion or destruction of land and growing stock are spread over so many people that most are not even aware they are bearing them. These costs spread out over such a long time that their effect is noticed only gradually and their origins are hidden in the past. Nothing can be done today to pass the social costs originating in the depletion of our forests back to the entrepreneurs who did the depleting many years ago. The best that can be done is to try to prevent such costs of present productive activities from being passed on to future generations.

Another class of social costs in forestry results from the kind of employment. The industrial accident and death rate is high in forestry. Part of the cost of logging timber is the damage suffered by the men who do the work. The real cost of accidents and deaths is hard to quantify. If a man's coat is torn up in the course of his work, his employer can compensate him by buying him a new coat of equal quality. But the employer cannot replace a leg or an eye which a man has lost in a logging accident. The real cost of such a loss to the man involved is impossible to determine.

The courts and the workmen's compensation laws try to arrive at a reasonable monetary compensation for these losses. But how can they compensate a widow and her children for the loss of their husband and father? Much of the cost of industrial accidents and deaths falls on the families and friends of the men involved and may extend over long periods of time. These social costs of forestry have been high in the past. At one time the lumber entrepreneurs avoided them almost entirely. Today the workmen's compensation programs pass a considerable part of the cost back to the entrepreneurs. Perhaps even more significant is the effort being put into the prevention of accidents and the provision for prompt and thorough medical care of those who are injured. This is one social cost of forestry which is being materially reduced.

Past incomes of workers in forestry have been low in many parts of the country. Many of the costs resulting from such low incomes were borne by society. Poverty and crime go hand in hand. The low-income families had to look to public welfare agencies for medical aid, relief during periods of unemployment, and support in their old age.

Incomes of forestry employees have risen along with those of all labor and perhaps to a greater extent than in some other industries. The minimum-wage laws have transferred part of the burden of adequate support that had been borne by society back to the entrepreneur. The social-security law has made part of the expense of supporting workmen and their dependents in their old age a direct production cost for entrepreneurs. The retirement provisions written into many union contracts are moved in this same direction. State unemployment insurance programs make part of the burden of supporting workmen and their families during periods of involuntary unemployment into a direct production cost. The total effect has been to reduce the social costs of forestry from what they used to be.

A final class of social costs arises from the instability of supply and price. Forestry has been characterized by violent fluctuations in output and in the prices of its products. One effect of this has been the high mortality rate of entrepreneurs in the forest industries. The elimination of inefficient entrepreneurs and firms is a desirable feature of a competitive economy. But every time a business fails, a number of people beside the entrepreneur himself suffer damages. Workmen are temporarily unemployed; creditors lose part of their accounts; investors lose part or all of their invested capital. Business in general may be disrupted in a small community by the failure of one firm.

Another undesirable effect is the underemployment of labor and capital. It is difficult for labor to shift temporarily to other jobs when a plant shuts down or curtails operations for a while. And it is almost impossible to shift the invested capital. Productive factors are assembled to produce at the peak rates and when activity declines part of this productive capacity stands idle.

This is particularly noticeable in the East, where many small sawmills operate only part of the time. When capital or labor resources are idle, the country loses the goods and services which these factors might have produced.

The United States has a national policy today of trying to maintain a high level of economic activity and to prevent major business fluctuations. If this proves successful, conditions in forestry will be more stable than they were in the past. But some of the recent stability of the national economy has resulted from so-called "rolling readjustments." While business in one industry slumped, other industries were active and the average remained fairly stable. Fluctuations in individual industries have been much more severe. Since forestry is a raw-material producer, continued fluctuations in activity and their resultant social costs probably can be expected.

Social Benefits in Forestry

Private benefits consist of all the returns which an entrepreneur receives from his productive activity. Social benefits, by contrast, are gains and desirable results of production which accrue to other persons or to society rather than to the entrepreneur who produced them.

No entrepreneur is able to retain personally all of the return that he receives from his productive activity. He must pass on a large part of his revenues to the people who provide the labor, capital, land, raw material, and other factors which he uses in production. Thus, the private benefits of production are distributed among all those who contribute to the productive activity (except for those who bear social costs). Social benefits are a problem because they originate in a situation where the entrepreneur cannot easily appropriate them. And the entrepreneur is not able to obtain any compensation from them for the cost to him of producing these benefits.

Aside from the ethical question of people receiving benefits without contributing in any way to their production, social benefits also affect the efficiency of resource use. As a simple example take a man who owns a rocky and eroded hillside field along a much-travelled suburban road. This field is an eyesore to the people who travel the road. The owner considers planting trees on the field and investigates the costs and probable yields of wood products. He learns that because of its poor quality the land will never grow enough wood to repay him for the cost of afforesting it. If the land were forested it would have considerable scenic value. So the people who travel the road would benefit from the conversion of an unsightly field to an attractive woodland. The total benefits — both scenery and wood — produced by afforesting the field would exceed the cost of doing the work. But a large part of the returns would be in the form of social benefits. There is no way that the landowner could charge the passers-by for the pleasure they would receive from looking at his property. To the landowner himself, afforestation appears to be an unprofitable undertaking and he will not go ahead with it. To society as a whole it would be a profitable undertaking and allowing this field to lie idle and ugly is a misallocation of resources.

Watershed protection is one of the more definite social benefits of forestry. The benefits of watershed protection are so widespread and accrue to so many different people that it is difficult even to estimate them. The man who takes over a tract of land in the headwaters of a stream, reforests the open areas, builds up a good forest floor by eliminating fire and grazing, and stabilizes the soil on his roads has some beneficial influence on everyone along the whole length of the rivers into which his stream flows. The results of his actions cannot be separated from those of other landowners, so it is hard to measure what he himself has produced. At the same time it is virtually impossible to measure the benefits which have accrued to the recipients. Social benefits obviously are being produced but there is no easy way of arranging to have the consumer pay the producer for them.

A social benefit that may be produced is stabilization of the communities where forestry production is carried on. Many people are affected by productive activity besides those who personally engage in it. A wood-processing plant may have 100 people on its payroll. Another two or three hundred members of the employees' families benefit from the pay checks they bring home. Many more people benefit when these pay checks are spent — grocers, doctors, filling-station operators, barbers, town officials. The processing firm also spends money locally for raw materials, supplies, utilities, and services of various kinds. This money too passes on to many others. All in all, virtually everyone in a community of ten thousand people is affected by the fact that the processing plant is there.

The stability of such a community depends on a steady flow of wood to the processing plant. If the plant has to shut down temporarily or operate at a reduced capacity, the whole town will be affected. Managing the forests which produce the wood for this plant on a sustained-yield basis so the plant can operate continuously, therefore, produces community stability as well as wood. The owners of the forest lands might be able to make just as much money from a form of management that produced yields at irregular intervals. But, if they operated in that manner, they would not produce the social benefits of stability. Such social benefits can hardly be appropriated by the landowners but the communities may recognize their importance and attempt in various ways to compensate the producers.

A third category of social benefits from forestry is reserve capacity for emergencies. In a war or other national emergency the amount of wood consumed increases greatly. It would not be a sound national policy to regulate our forests to produce exactly the amount of wood consumed under normal, peacetime conditions. We are not too sure what our future population and demand for wood will be, even if there are

no more major wars. It appears preferable to err on the side of long-run overproduction rather than underproduction. Maintaining a reserve supply of timber on the stump and a productive capacity in excess of current demand places a burden on forestry entrepreneurs. Part of the benefits they produce take the form of insurance against a shortage of wood in a future emergency. But this is a social benefit that accrues to the country as a whole and there is no easy way in which the entrepreneurs can claim compensation for producing it.

Society and Forestry

Many important costs and benefits in forestry production are social rather than private. From a national viewpoint these social costs and benefits have a significant influence on the rational use of our forest resources. In making decisions based only on what affects them privately, individual entrepreneurs may ignore some of the most important costs and benefits. Unless the social costs and benefits are somehow included in the economic analysis there is little likelihood that the use of our forest resources will be completely rational.

In a theoretical situation in which there is perfect competition among producers and among consumers and where all the costs and benefits attach to the parties involved in the production and exchange, the efforts of the individual entrepreneurs to maximize their own profits would simultaneously maximize the welfare of society. But in our real economic situation we do not have perfect competition and we do have social costs and social benefits. So unrestricted private enterprise would probably fail badly to maximize the welfare of society as a whole.

Because of this, the activities of individual entrepreneurs are restricted in many ways. The most obvious restrictions take the form of government action and regulations. But many other institutions influence or restrict the individual in his economic activity — trade associations, labor unions, better-business bureaus, civic clubs, and chambers of commerce, to name a few. In addition, the large corporations do not behave like private individuals. The effects of their actions are so widespread and so obvious that most of them have developed a "social conscience". They realize that, because of their size and diversity of interests, actions which are good or bad for society as a whole are also good or bad for them as individual corporations.

The point to be stressed here is that the free working of the market system cannot by itself bring about efficient use of our forest resources. It is necessary that other controls — governmental or institutional — be brought to bear on the use of these resources. This has been and is being done. There is a considerable difference of opinion about the form which such controls should take and the extent to which they are necessary. But there is little disagreement about the fact that the social costs and social benefits involved in the use of our forest resources are so great that some such action must be taken.

SAINT JOHN GUALBERTO

For several years now *La Festa della Montagna*, the Mountain Festival, has been celebrated in Italy. It has the active support of local and national government, and is attended by large crowds of people. The festival takes place every year in a different place in the mountains of northern, central and southern Italy on one of the early Sundays in July, when there is a succession of religious functions and items of folklore interest and entertainment. It is in this month too, on the twelfth, in fact, that occurs the Feast day of Saint John Gualberto, founder of the Vallumbrosan Order, whom His Holiness Pius XII in an Apostolic Brief dated 12 January 1951, proclaimed the Patron before God of the Foresters of Italy.

John Gualberto Visdomini was born in the year 995 into a noble and rich family, descending from an ancestor knighted by Charlemagne, while his mother was an Aldobrandini. From his early youth he bore arms and was soon numbered among the best knights of Florence, so well versed did he become in the ways of chivalry. One day, so the story goes, his elder brother was killed by a distant relative and John was charged by his aged father, following the custom of the time, with the task of avenging his brother and restoring the family honor. On Good Friday of 1028 he met up with his brother's killer and had him completely at his mercy. He was about to run him through, when, regardless of what his family, friends and society would think, he cast his sword aside and, forgiving his enemy, embraced him. Feeling that through this act a complete change had taken place within him, he immediately entered the nearby church of San Miniato to offer thanks to God for this self-conquest and threw himself at the feet of a painting of Christ which, suddenly alive, bowed its head towards him in sign of approval. Moved by this divine intervention, the young Visdomini resolved to renounce the life of ease and honor proper to his state. He entered the monastery attached to the Church and put on the Benedictine habit.

The corruption, which was at that time to be found among some ecclesiastics in Florence and elsewhere,

(*Continued on page 172*).

Forest Tree Breeding Research

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In preparation for the World Seed Year, FAO is seeking to assist national campaigns aimed at improving seed quality and promoting wider use of such improved seeds. An important element in the production of better seed and superior trees is research relating to genetics, and particularly to forest tree improvement. The subject of forest tree breeding research is being treated by Professor Mergen in two parts. In the previous issue of Unasylva, *he dealt with individual tree selection, progeny and clonal tests, and vegetative propagation. In this article he deals with hybridization, controlled pollination, and induction of flowers and fruits. Forest tree breeding research is potentially of the greatest significance to foresters and forest products industries. Interested readers are invited to send their comments to the Director, Forestry and Forest Products Division, FAO, Rome.*

When plant geneticists use the term hybridization, they mean all crosses between parents that are genetically unlike. Included are crosses within species (intraspecific) as well as crosses between species (interspecific). Foresters, on the other hand, are generally referring to interspecies hybrids when they discuss the place of hybridization in forest tree improvement programs. The term will be so restricted in this paper.

Natural Hybridization

Hybridization, *per se*, has probably always occurred amongst forest trees, but has not been seriously studied until fairly recently. Natural hybridization between compatible species brings about a convergence or blending between the traits of the parent species and, if fertile F_1 and F_2 progenies are produced, it allows genes to flow from one species into the other. These hybrids occasionally also form a bridge or by-pass between two species that are not compatible.

Natural hybridization takes place when two compatible species grow under sympatric conditions (occupy same area) and when the flowering season of the two species coincides. Because the F_1 hybrids differ from the parent species in morphological and physiological qualities, their site requirements may also differ. Consequently, although fertile seed and seedlings might be produced from the cross between two species, these new trees are able to survive and perpetuate themselves only if they can find a suitable ecological niche. If they are able to establish themselves, they either cross-pollinate between themselves, or back-cross to either or both of their parents, or to a possible third species. There is one natural hybrid pine in Mississippi, of which some of the open-pollinated progeny display the characteristics of *Pinus palustris*, *P. elliottii*, and *P. taeda*.

This type of cross-pollination is essentially at random, and in natural hybridization no man-directed selection takes place. It is purely a chance phenomenon with limited practical application, although it is of extreme interest to the students of evolution and taxonomy. The frequency of natural hybridization varies considerably with the genera, and is more prevalent in some than in others. A good example of natural hybridization can be found in the genus *Quercus* and, as an example may be cited the conditions in the State of Pennsylvania, U.S.A., where 17 species of oak occur naturally. Some 18 different natural hybrids between oaks that occur in this State have been described in the literature (Chisman, 1955). These crosses were all between parents belonging to the same group — white oak (*Lepidobalanus*) or red oak (*Erythrobalanus*), — for each group has a different post-fertilization cycle. Of interest also is a note by Syrach Larsen (1956) that the famous 800- to 900- year-old "twisted oak" (*snoegen*) in Denmark is apparently not a true *Quercus robur*, but a hybrid between *Q. robur* and *Q. petraea*.

Despite the large number of natural hybrids that have been identified and described, there are few instances where natural hybrids have appeared superior to either of their parents or where they have found their way into artificial planting projects. The best known instance of a promising natural hybrid is the cross between the Japanese larch (*Larix leptolepis*) and European larch (*L. decidua*). This natural cross occurred after Japanese larch trees had been introduced into Scotland where they were wind-pollinated by European larches. The resulting hybrid, *Larix* × *eurolepis*, as it was named by Dr. A. Henry, has rapid growth and good form, but above all it shows resistance to the larch canker, and is comparatively free from attacks by *Chermes* (Larsen, 1956). The natural hybrid *Salix* × *coerulea* (Cricket-bat willow) received its name by virtue of its wood that is particularly well suited to the manufacture of cricket bats (Schreiner, 1937).

FIGURE 1. – *Hybrid between* Pinus elliottii *and* Pinus palustris *in a test plantation at Olustee, Florida. The tree was photographed at the beginning of the ninth growing season, its height being 7 meters, and the d.b.h. 13.5 centimeters.*

Courtesy, U.S. Forest Service

Of interest is the fact that the recently described *Picea* × *lutzii* from the cross *P. sitchensis* × *P. glauca* from the Kenai Peninsula in Alaska, is being used for afforestation in Iceland. Although the hybrid seedlings do not possess any advantages over their parents in their native habitat, seed was collected from this hybrid in Alaska and the seedlings were raised in a forest tree nursery in Iceland (Baxter, 1956).

The outstanding natural tree hybrid is the red-flowered horse chestnut, *Aesculus* × *carnea*. This is a true-breeding natural hybrid between *A. hippocastanum* and *A. parvia*, which has twice the number of chromosomes of the parental species (Skovsted, 1929). This double set of chromosomes from each parent allows this amphidiploid hybrid to perpetuate itself, since crossing-over of random assortments will not produce any new combinations. Another hybrid that has been used in large numbers for ornamental purposes, although it has little importance as a forest tree, is the cross between *Platanus occidentalis* and *P. orientalis* (Rehder, 1937). This natural hybrid is known as the London plane tree (*Platanus* × *acerifolia*), and clones are used in both Europe and on the American continent.

CONTROLLED HYBRIDIZATION

In natural hybridization, man, as has been said, does not exert any guiding influence, except in those instances where non-native trees are introduced on their own merits and then cross-pollinate with compatible native trees, or when man's interference with nature has created ecological conditions favorable to either cross-pollination or to the establishment of hybrid seedlings. In controlled hybridization, on the other hand, trees with desirable characteristics are crossed in an effort to obtain offspring with the desirable traits of two or more parents or parental species.

Under these circumstances many of the conditions required for natural hybridization are of no consequence. The ranges of the two species do not have to overlap, the trees need not grow within wind-pollination distance of each other, the receptive period of one species does not have to coincide with the pollen shedding of the other, the seed is germinated under optimum conditions, a favorable environment is artificially created for the seedlings or trees, and even some inherent incompatibilities have been by-passed by embryo-culture.

In nature, most of the forest-tree genera have extensive ranges and some encompass the most diverse climatic and edaphic site conditions. A good example of this is found in the genus *Populus* whose members occur naturally throughout Europe, North America, North Africa, and in Asia, with its northern boundary extending to the timber line beyond the Arctic Circle. Another genus with which extremes of site conditions are encountered is *Pinus*. *Pinus serotina* grows in swamps, while the forests of *P. clausa* are located on dry, sandy soils. The variation in altitude within some species is just as great, ranging from sea-level to the altitudinal timber line.

Besides an ability to grow under the most severe site conditions, there are other great genetic differences in physiological and morphological conditions encompassed within a genus, such as resistance to a particular insect or disease, types of root systems, bole and crown shapes, or ability to perpetuate themselves by sprouting, just to name a few features. Theoretically, this natural genetic diversity of desirable traits presents good opportunities to breed almost any type of tree suited for a particular environment. The apparently unlimited possibilities, along with the outstanding performance of hybrids in agriculture, has caused some foresters to become overoptimistic and talk about super-hybrids that would solve most of their silvicultural problems.

The actual situation insofar as the place of hybridization in forest tree improvement work is concerned, is as follows. The results of past hybridization experiments have shown firstly what hybrid crosses can be made or are possible and, secondly, how these hybrids compare with their parents. In view of the large number of species and their world-wide importance, members of the genus *Pinus* have received the greatest attention amongst the gymnosperms, and members of the genus *Populus*, for equally apparent reasons, have

been used most extensively in hybridization work amongst angiosperms.

Since 1845, when Klotzsch first attempted to produce artificial hybrids between forest trees (Klotzsch, 1854), sporadic reports of other attempts appeared in the forestry literature. It was not until 1924, however, that the first sustained efforts were made by the Oxford Paper Company, in Maine, U.S.A., to produce hybrids of members within the genus *Populus* (Stout, *et al.*, 1927). During the existence of this program some 13,000 hybrid seedlings were obtained from crosses involving members of 34 species, varieties or hybrids of poplars (Schreiner, 1935). The early interest in poplar breeding was possibly also based on the spontaneous occurrence of two cultivated fast-growing poplar strains in France. Both of the cultivated poplar clones *Populus* × *euramericana* cv. *eugenei* and *Populus* × *euramericana*[1] cv. *robusta* originated in the same nursery (Anonymous, 1958). The interest in poplar breeding has in no way slackened, as evidenced by the reports of the International Poplar Commission.

In a recent publication by Schreiner (1959), *The Production of Poplar Timber in Europe*, the history and importance of poplars in Europe is reviewed. France, although leading Europe in poplar acreage (247,000 acres or 99,000 hectares), is surpassed by other countries in the productivity and intensity of its poplar culture. In the Po Valley of northern Italy, e.g., when planted on fertile, agricultural land and grown on a 12- to 25-year rotation, poplars can produce a greater cash return than other agricultural crops. Many of the poplars planted in this area are selected clones of natural hybrids between *Populus deltoides* which was introduced from North America around 1790 and the native black poplar (*Populus nigra*). These natural hybrids have been subjected to vigorous selection and progeny testing, and the outstanding work by Dr. Piccarolo and his associates of the Institute for Poplar Research at Casale Monferrato has led to the isolation of several clones that are especially well suited for planting in Italy. It is of interest that the majority of the clones that are planted in Europe are also cultivars of natural hybrids, e.g. *Populus* × *berolinensis* (Denmark, Germany, Norway, Sweden), and *Populus* × *euramericana* (Holland, France, Belgium, Germany, United Kingdom).

Poplars lend themselves well to genetic studies for they flower at a fairly early age, the flowers can be forced to maturity in the greenhouse, and all poplars can be propagated vegetatively in different ways. Currently, there are no less than 25 different institutes throughout the world actively engaged in research on the genetics and breeding of poplars. Hybrid poplars (*Populus tremuloides* × *P. tremula* and *P. deltoides* × *P. trichocarpa*) of improved growth rate over the native European poplar are available commercially in Europe and are being used widely in artificial regeneration, especially in Sweden, Denmark, and also in Finland. The results from poplar breeding have nicely demonstrated the necessity for adequate clone and progeny testing before claims can be made as to the superiority of a particular cross. Often the hybrids showed improved growth in the nursery beds, but in the out-plantings they failed to maintain this rapid juvenile growth and some formed stagnated stands. In addition, many of the hybrids are susceptible to various diseases, possibly as a result of an unbalanced physiological condition in the F_1 hybrids. An example of this is found in the F_1 progeny of *Populus deltoides* × *Populus trichocarpa* (*P.* × *generosa*) which is characterized by rapid juvenile growth but becomes susceptible, as the trees grow older, to the weeping canker. Research efforts are being directed towards finding resistant clones of this cross. The progeny tests also provided good statistical evidence that the growth performance of a species cross is highly variable and greatly depends on the individual parents used in a particular cross (Anonymous, 1958).

In 1925, the Eddy Tree Breeding Station, later known as the Institute of Forest Genetics, was organized at Placerville, California, and started work on the genetics of pines. The first task was to accumulate as many species of pines as was physically possible, so that the genetic potential or variability within this genus could be fully utilized in hybridization work. More than 40 F_1 hybrids have since been produced at the institute (Righter and Duffield, 1951), many of which have been highly fertile, and some of these crosses have produced seed in large quantities. An annotated list of 23 of their most promising two-species and three-species hybrids was prepared by Duffield and Righter (1953), in which a digest of their performance is given.

The results demonstrate that the majority of hybrid progenies are not superior in growth rate to their parents, although some crosses have yielded trees that showed great promise. On the other hand, it must be conceded that a hybrid can have great economic importance without being superior to either of its parents, by virtue of its ability to grow under a wider range of climatic conditions or by possessing the desirable traits of the parent species. For example, the tri-species hybrid resulting from the cross (*Pinus ponderosa* × *P. latifolia*) × *P. montezumae* has, when grown at Placerville, California, the exceptional height growth of Montezuma pine, the early diameter growth of Apache pine and the local adaptability of ponderosa pine (Righter, 1955). Another interesting hybrid is the backcross of *P. jeffreyi* × *P. coulteri* to *P. jeffreyi*. The results from cage-tests indicate that this hybrid shows resistance to the pine reproduction weevil, a pest that has caused high mortality in plantations of ponderosa and Jeffrey pines in northern California (Miller, 1950).

The progeny from the cross between *P. palustris* × *P. elliottii* var. *elliottii* which was the first made by Philip C. Wakeley of the U.S. Forest Service in 1931, was outplanted for testing outside the natural range of both parent species in Placerville, California. The juvenile growth of this hybrid and its reciprocal which

[1] *P.* × *euramericana* is referred to as *P.* × *canadensis in the USA.*

has been repeated on many occasions since, is intermediate between both parents and does not have a "grass-stage" which, in longleaf pine, can last up to 20 years. Although not adequately tested as to progeny, this hybrid may be suitable for planting on dry sandy soils and on other sites (Figure 1).

In the Haploxylon pine group (white pines) most of the hybridizing, along with selection, is concentrated towards producing a suitable timber tree that is resistant to the white pine blister rust and the white pine weevil. The early performance of some of the crosses has been most promising and warrants greater efforts.

Controlled hybridization work with members of the genus *Picea* is of fairly recent origin, and in most instances data are available only on the nursery performance and on early survival in plantations. The results from the crosses give, however, some idea of the cross-ability pattern of this genus.

A total of 70 different species crosses have been attempted by tree breeders throughout the world. Of these 16 yielded viable seed, 12 were apparently successful, and 42 were complete failures. Of interest is the fact that of the 16 successful crosses, 14 of the species used in these crosses had neighboring natural ranges or were morphologically similar, or both. In the 42 crosses that failed, 37 of the species involved had ranges that were widely separate (Wright, 1955).

As mentioned before, the performance of the "Dunkeld" larches caused several tree breeders to collect open-pollinated cones from these natural hybrids or to repeat the cross. The progeny from some of these are superior in height growth to either or both Japanese and European larch, with no apparent change in form (Larsen, 1956). However, further work is needed with this cross using parents of known origin, along with adequate progeny testing.

After the chestnut blight had killed vast numbers of *Castanea dentata* trees in the United States, large-scale attempts were made to eradicate the disease by mechanical and silvicultural means. These costly efforts proved worthless, but new hopes were generated by the fact that the Asiatic chestnuts, *C. crenata* and *C. mollissima*, are resistant to this blight and can be crossed successfully with the American species. Despite the considerable amount of work that was carried out in both the United States and Europe, tree breeders have not produced a tested chestnut hybrid that is a suitable forest tree and is fully resistant to the blight (Figure 2). The work with chestnuts has been a particularly difficult one because the American chestnut did not possess a blight resistance factor in any one of its members, the Asiatic chestnut trees have a poor form, and the seed set from controlled pollination has been low. This breeding work has produced, however, some promising hybrids from the cross between *C. mollissima* and selected trees from the F_1 progeny of *C. crenata* $\times$ *C. mollissima*. Some of the resulting hybrids, although not suitable for timber trees might find their way into commercial nut orchards (Nienstaedt and Graves, 1955).

Besides the genera mentioned, controlled hybridizing is being done with trees of the following important forest tree genera: *Abies*, *Araucaria*, *Tsuga*, and *Acer*, *Betula*, *Eucalyptus*, *Fagus*, *Quercus*, *Tilia*, *Fraxinus*, *Ulmus*.

Once an outstanding hybrid has been produced on an experimental basis and has shown its superiority in progeny or clonal tests, it needs to be mass-produced for use in commercial plantings. This can be done by either vegetative propagation of the desired individuals, by repeating the cross, or by producing amphidiploid hybrids. If biologically feasible, the quickest way will be to repeat the cross. If vegetative propagation has to be used, clonal tests are necessary before a particular clone can be recommended. There might be some instances, however, where only a few individuals in an F_1 population are of the desirable type, in which case clonal propagation is advised.

The main shortcoming of hybridization attempts with forest trees so far is that the resulting hybrids are too young to permit drawing any reliable conclusions. Before one can state that a particular cross has hybrid vigor, or heterosis, adequate replicated progeny or clonal testing should be done within the natural ranges of both parents. The policy of the Institute of Forest Genetics at Placerville has been to send out quite large quantities of hybrid seed to reliable co-operators throughout the world, so that these hybrid trees might be tested under varied conditions.

It is also often difficult to locate trees for hybridization experiments that have an authenticated history. The result from several crosses have shown that the genotype of the trees used greatly affects the offspring. Such factors as geographic and altitudinal ecotypes must therefore be taken into account in these trials.

However, the results from hybridization work to date has laid a good foundation for future programs. It has shown that hybridization on a fairly large scale is feasible with forest trees and that, in some instances, hybrid seed can be produced at economically feasible prices. There are reliable performance records in regard to a number of hybrids, and in many instances they have shown great promise: some were superior to either or both of their parents in growth rate, and resistance factors to certain insects and diseases were also present in some of them. Also the cross-ability patterns have yielded much valuable scientific knowledge and allowed the revision of the systematics of some forest tree genera, especially within the hard pine groups (Duffield, 1952).

Controlled Pollination Methods

Controlling the pollen source during the pollination of forest trees is now an accepted practice throughout the world. Its purpose is to present undesirable wind-borne, or insect-borne, pollen from reaching the receptive female flowers of certain selected individual trees, or groups of trees. The techniques are quite variable and depend on the intensity and goals of the various programs and on the personal preference of the tree breeder.

They can be divided into two main categories: cross-pollination under natural but controlled conditions, or pollination by hand.

There is currently much discussion on the establishment of seed production areas and seed orchards to supply forest tree seed of good quality. The seed production areas have been discussed under the section on tree selection (*Unasylva*, Volume 13, Number 2, pages 81 to 84), and need no further mention at this point. Seed orchards, on the other hand, are, by definition, plantations of trees that are *genetically* superior, and that are managed for the sole purpose of producing high (genetic) quality seed. These orchards resemble apple orchards to a greater degree than a forest stand, for the trees are planted at a wide spacing and they will be cultured so that they have large cone-bearing crowns. They will be established either with clonal material such as cuttings or grafts, or with seedlings.

Because the operation of seed orchards is new to forestry, many problems need to be worked out, such as: minimum number of clones per orchard to prevent inbreeding depressions in the resulting progeny; width of an isolation strip to prevent stray pollen from reaching the flowers; type of fertilizer to use; arrangement of clones to obtain a maximum amount of cross-pollination; protection against insects, disease, rodents and birds; and many other problems more common to agriculture than to silviculture. Since the inception of seed orchards, sizeable areas have been planted for this purpose. The first seed orchard in the United States, with grafts from proven genetically superior trees was established with *Pinus elliottii* for the production of trees for high yields of naval stores products (Mergen, *et al.*, 1955). It has, however, become practice to establish seed orchards with clones from superior phenotypes before the genetic superiority of these trees has been proven, and while the progeny tests are being made concurrently. In these instances, individuals that do not show any superiority in the progeny tests will be cut out.

Many of the ideas and concepts on seed orchards originated in the Scandinavian countries. The Society for Practical Forest Tree Improvement in Sweden has

FIGURE 2. – *Control pollinating Chinese chestnuts in a plantation at Hamden, Connecticut. The trees with the drooping catkins are hybrids between* Castanea cremata *and* Castanea dentata.
Courtesy, B.W.McFarland, Connecticut Agricultural Experiment Station, New Haven, Conn., U.S.A.

been a leader in the establishment of large-scale orchards, for seed of *Pinus sylvestris* and *Picea abies*. Arnborg (1956) estimated that the Scots pine orchards will start to produce seed in sizeable quantities when the orchard is 10 years old, and that each acre will yield enough seed at age 20 for about 300,000 seedlings.

The estimate by Dr. Larsen (1956) for larch, based on the performance of grafts, is that each acre will produce seed for 360,000 trees. In the United States, seed orchards of *Pinus elliottii*, *P. taeda*, *Pseudotsuga menziesii*, and *Tsuga heterophylla*, among others, are being established at an almost alarming rate. In the State of Georgia, for instance, a program has been initiated to establish 400 acres of seed orchards to supply part of the annual seed requirements for 350 million seedlings (Figure 3). The orchards are established by grafting the scions either directly on stock in the fields or the forest owners collect the scions from their selected trees and ship them to a central grafting place.

After unions are formed, the grafts are outplanted in the field. Besides providing seed of superior genetic quality, some forest companies are establishing seed orchards solely to assure adequate seed supplies of average genetic quality for their accelerated reforestation programs.

Another type of seed orchard was proposed by Righter (1946) of the Institute of Forest Genetics for the mass production of pine hybrids. He argued that, because genetic uniformity is not required or even desirable in silviculture, a variable F_2 hybrid progeny might be used advantageously. Its seed could be produced on a mass-scale in seed orchards planted with F_1 hybrids that are allowed to interbreed amongst themselves.

The controlled pollination practices described so far have dealt with entire trees or groups of trees, and are used mainly in the mass-production phase of tree improvement programs. Before this step can be undertaken, however, a great deal of hand pollination by the forest geneticists is required. When trees are hand-pollinated, the female flowers are isolated with pollination bags, and the selected pollen is then placed on these flowers when they become receptive (Figure 4).

Various types of bags have been used, e.g., glassine and polyvinyl bags, viscose sausage casings, Kraft paper and canvas bags, or plastic tubes (Figure 5). Plastic sausage casings have been widely accepted by tree breeders because they allow continuous observation of the development and condition of the flowers, air and moisture can pass through the walls, and the material is strong enough to withstand rough treatment. Recent tests, however, have shown that the temperature inside bags that are exposed to full sunlight can rise to a point where it may damage the pollen. This undesirable effect can be overcome quite easily by spraying the exposed side with white or aluminum paint.

Sometimes, when abundantly flowering trees are being used, it is expedient to isolate entire trees with tents. At Ekebo, Sweden, tents made with seven sections of a parachute are used. One of the advantages of this is the fact that the same tent can be used on several species of trees having successive periods of flowering (Johnsson, 1953). At the Petawawa Forest Experiment Station, at

FIGURE 3. – *Overall view of a newly established seed orchard of* Pinus taeda *of the Georgia Forestry Commission. The scions from selected trees were grafted directly onto seedlings in the field. The spacing between trees is 16 × 16 feet (4.87 × 4.87 meters). All the selected trees are being progeny tested while the orchard develops, and the poorest genotypes will be removed in future thinnings.*

Courtesy, Georgia Forest Research Council, Georgia Forestry Commission, and U.S. Forest Service

FIGURE 4. – *Process of control pollinating an F_1 generation of* Pinus elliottii *in an 8-year-old progeny testing plantation at Olustee, Florida. The ladder equipped truck allows rapid movement from tree to tree without damage to the tree crowns.*

Courtesy, U.S. Forest Service

FIGURE 5. – *Four types of isolation bags in a test on* Pinus elliottii *at Olustee, Florida. They are, in a clockwise direction: Kraft paper, canvas bag with plastic window, clear plastic, and viscose sausage casing. The black tape on the bags closes the puncture made by the needle of the pollen injector.*

Courtesy, U.S. Forest Service

Chalk River, Ontario, a tent mounted on a pole has given good results with *Picea glauca*. The tent is manufactured of canvas, and is held open by hoops, and several hundred female flowers can be isolated in this manner.

When female flowers are isolated it is necessary that the male components be removed beforehand to prevent contamination from the tree's own pollen. Isolated trees are occasionally found that have only female flowers, and Wright (1955) used some of these trees without isolation bags in his spruce hybridization program. If a particular hybrid seedling shows enough variation from the nonhybrids, this technique is possible, and apparent contaminants can then be weeded out in the nursery beds.

When the female flowers become receptive, pollen is either dusted or blown on the flowers. The pollen is collected beforehand, and considerable quantitites are sometimes necessary, especially when the flowers of an entire tree crown are isolated. For the conifers, in general, it is customary to collect the pollen from tree-ripened microsporangiate strobili (male flowers), while, for some of the hardwoods, forcing of male flowers in the greenhouse gives good results. With such species as aspen or poplars that ripen their seed some four to seven weeks after the flowers are pollinated, the entire process can be carried out with good results in the greenhouse. Flower-bearing branches are cut during late winter and forced into flowering by placing their cut bases in water and keeping them in a heated greenhouse. Viable pollen will shed from the male flowers and is dusted on the receptive female flowers; after a period of several weeks, the ripe seed capsules can be harvested.

The largest hand pollination program ever attempted was at the Institute of Forest Genetics at Suwon, Korea. Under the direction of Dr. Hyun about 60,000 ovulate strobili of *Pinus rigida* were isolated, using some 30,000 isolation bags. Approximately 1,200,000 hybrid seedlings of *P. taeda* × *P. rigida* resulted from this operation,

at an average cost of $6.00 per 1,000 hybrid seedlings. This program is being continued and expanded.

Pollen from some species, such as the spruces, will remain viable during a period of one to several years if stored under the proper conditions of temperature and humidity. This long period of viability makes it possible to cross species that flower at different periods of the year. If stored pollen is used, it is advisable to make germination tests beforehand to avoid the use of dead pollen. Currently, there is a wide exchange of tree pollen between tree breeders throughout the world, for air transportation provides a speedy vehicle of exchange without any loss in viability during transit.

The time interval between pollination and seed shedding presents ample opportunities for various insects, fungi, rodents, and climatic factors to decimate the potential seed crop. This is of especial concern for members of the genus *Pinus* where a period of about three years elapses from the time the flower primordia are laid down until the seed ripens in the cones. Insects have been combatted by spraying with D.D.T. or B.H.C., and during this past year spraying with fungicides from an airplane was used to protect the flower crop in a seed production area of *P. elliottii* in the State of Georgia (Cole, 1958).

It has become an accepted procedure with some species either to leave the isolation bags over the flowers or to place a special bag over the developing cones or nuts (chestnuts) to protect them from dropping to the ground: this also minimizes the damage from rodents and birds.

Flower and Fruit Induction

The rate at which the science of forest genetics will advance is dependent on the time it takes to evaluate progeny tests, and on the interval between successive generations. To make controlled pollinations, flowers of both sexes are a prerequisite. But the general field of flower induction and fruit formation in forest trees has been neglected until recently, and considerable basic research is needed.

Until foresters started to breed forest trees, few people had closely observed their flowering and fruiting behavior. Most tree flowers, although quite interesting when examined closely, are not showy when viewed from a distance and, being mostly in the upper portion of the crown, they do not attract much attention. As a result, little or no precise information is available for the various species on the minimum age when flowers appear, on the ratio of male to female flowers, and on the factors that control flowering in general. A record of early flowering among 57 species or varieties of pines growing in the pinetum at Placerville, California, was published by Righter in 1939. The average minimum age at which staminate flowers appeared was 4.4 years, and 5.2 years for the ovulate flowers. One species, *Pinus tabuleformis* bore male flowers during the first year. The writer has collected viable pollen, as tested by actual germination, from three Mugo pine seedlings (*P. mugo* var. *mughus*) that were less than one year old. The reason for the precocious flowering in some trees is not known.

Numerous attempts to induce flowers experimentally in one- or two-year-old trees have been only moderately successful. In somewhat older trees that were closer to the normal flowering age, however, various techniques have yielded good results, for instance the addition of N.P.K. fertilizers to the soil, either singly or in mixture. These experiments have not so far covered a large enough variety of soils and species to allow any general recommendation to be made but one can deduce from past examples that almost any addition of a balanced fertilizer will improve the vigor of the tree and stimulate flower production. Besides this stimulation with nutrient elements, physical injury to the roots or stem has been successful in some cases. Such treatments as root pruning, stem strangulation, and various degrees of girdling have increased the flower crop. These treatments, although of a physical nature, affect the normal translocation of organic assimilates and have a tendency to accumulate the photosynthates above the injury.

Sax (1957) obtained significant flowering effects by inverting the bark in apple trees; this technique, however, has failed so far to yield results with forest tree species tested. Mirov (1951) was able to induce flowering during the third growing season, in five species of pine by grafting young seedlings into the crowns of a *P. ponderosa* tree that was flowering heavily. This technique has since been tried repeatedly without, however, giving consistent success. The external application of hormones or auxins has as yet failed to bring about flowering in a replicated experiment. Fruit induction, without viable seed, as a result of treatment with auxins is economically sound in the field of agriculture where the fruit is the principal crop, but this technique has no place in forestry where the only concern is viable seed. It might be pointed out, however, that berries will form from unpollinated female flowers on holly trees if they are sprayed at the proper time with indoleacetic acid.

If the sex of flowers could be altered at will, it would also help the progress of the hybridization experiments. Little work has been done along these lines, but Dr. Saito (1957) was successful in controlling artificially the sex differentiation of *P. densiflora* and *P. thunbergii* by injury to the shoot or by spraying with aqueous solutions of either alphanaphtaleneacetic acid or 4-dichlorphenoxyacetic acid. In each instance sex transition was from a rudimentary male strobilus to a female strobilus.

Conclusion

Controlled hybridization of forest trees has helped to advance considerably scientific forestry knowledge. Motivated usually by practical considerations, it has stimulated much basic work on the physiology, cytology, and general behavior of forest trees. The evidence obtained so far on interspecies hybridization should be most encouraging to the practicing forester, for it has

shown that the desirable traits of two or more species can be combined in one individual. This approach to obtaining trees better adapted to silvicultural treatments will, if combined with other methods of improvement, such as selection or treatment with mutagenic agents, always deserve a prominent place.

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Equipment for Pest and Disease Control

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The application of pesticidal dusts, dilute sprays, concentrated sprays and aerosols, for the control of pest and diseases in agriculture and forestry, has become widespread. The method has not approached its potential of use and many areas could be treated more efficiently and effectively, and at a lower cost, if better data and information were readily available. This paper, continued from the last issue of Unasylva, *describes present practices in North America and, besides dealing with insecticides and fungicides, includes information on equipment and methods for applying the new herbicides, silvicides, foliage nutrients and fertilizers. The possible harmful effects of the extended use of chemical control methods in agriculture and forestry are of much concern to FAO and many other agencies. These effects are being studied but much more data needs to be collected.*

Aerial Equipment

The airborne end

Almost everything mechanical that will fly — even airships — has been tried for crop spraying. Pest-control jobs — some spraying, some dusting — keep more than 6,000 planes and 7,000 pilots busy in the United States.

If you have a choice as to the kind of craft to hire, the main thing to consider is the job you want done. Points to think about include:

How big are your forests and fields?
How close are they to landing strips?
What kind of country will the plane have to fly over?
Can the plane carry a big enough load to hold down costs?
Is it fitted with the proper spraying equipment?

In general, four types of planes are at work on forest and crop-spraying projects. All have their advantages and disadvantages. A good many of those in use today are converted surplus military training planes, which are cheap and easy to handle.

Light planes are well suited to most jobs in farming country. They can be bought and operated at relatively low cost, they maneuver well in tight quarters, and, in an emergency, they can be landed in pastures and on roads.

Spraying rangeland or a forest usually involves greater ferrying distances and larger acreages than spraying crops. For such a job, planes such as the twin-engine Douglas DS-3 have distinct advantages over light planes — longer range and bigger payload.

Helicopters also have a place in the spraying picture. They are more expensive than light, fixed-wing aircraft, but sometimes they can make up for it by their ability to take off and land straight up and down, without a runway. This saves mileage and time, and makes it easier to handle small, hemmed-in fields. Other advantages are that poor flying visibility handicaps helicopters less than it does fixed-wing aircraft, and the downwash from the rotors helps to push the spray deep into the crop.

No matter what plane you choose, it will carry spraying equipment that belongs to one of two general types. In one type the equipment includes pumps that discharge the pesticide from the plane. The other type lets gravity do the work, the way a sprinkling can does.

Most experts think that pumps do the better job. Without some pressure behind the spray, it is hard to get an even, controlled flow and good atomization.

There is a bewildering variety of spraying equipment. Dozens of different systems and devices have been developed, each with its own strong points and weaknesses. When making a choice, it is a good idea to keep in mind this basic question: Is this the equipment that will get the pesticide onto my crop in the most efficient way?

In general, good equipment should —

1. spray out the pesticide from the plane at a uniform rate;
2. provide for an adjustable rate of discharge, so that crops get the right number of gallons of spray per acre;
3. spread the liquid in as wide a swath as possible beneath the plane;
4. avoid putting down too heavy a deposit in the center or at the edges of the spray swath.

A spray outfit ordinarily has —

1. a tank, to hold the pesticide.
2. a pump, to move it out.
3. a piping and control system, to carry the right quantities of liquid from the tank to the boom;
4. a boom-and-nozzle assembly that atomizes the liquid — that is, breaks it up into the right-sized spray particles, so that it can be spread properly.

Special jobs may call for special apparatus. Designs are changing constantly. The main thing for you, as a forester, to remember is that spraying is a technical job. If you are not sure that the man you plan to hire has the right equipment, step right up and ask some questions of the operator.

If you own a plane and want to handle the spray job yourself, you can buy spraying rigs, complete, for some of the popular makes of plane. They can be removed readily.

Spray-plane piloting

Many special techniques of spray-plane piloting have been developed. The trick is to lay down exactly the right dosage of pesticide with as few passes as possible. If the plane makes too many circuits, costs go up and time is wasted. If it makes too few, coverage is not even and the pests are not killed.

Standard practice in spraying fairly flat, rectangular fields is to follow a grid pattern. The pilot flies back and forth across the area in parallel lines. He holds the distance between the flight lines the same as the effective swath width of the spray plane.

Swath width depends on altitude, wind, plane, and equipment. Measuring it requires field tests. The part of a swath that receives approximately the recommended per acre dosage of pesticide is called the effective swath.

If you're an operator

For safety's sake, pilots should fly crosswind, and should move upwind on each successive pass so that there is no chance for the poisonous spray to blow back on the plane.

When feasible, start the turnaround at the end of the spray run with a 45-degree climbing turn downwind, over the land adjoining the part of the field already treated. Then level off and reverse the turn 225 degrees. As you come around, orient yourself and line up for the next run. Then, with power reduced, let down to spraying height and start the new pass.

Be sure to fly long enough on the downwind leg of the turn to allow room to complete the 225-degree swing without crowding or arriving too far upwind to start your next run. The aim is to avoid making tricky turns to get into position.

If the 45-degree starting turn is made upwind, you may have to crowd the 225-degree turn and cross your slipstream to start the next run. This should be avoided.

When the country is rough and the area to be sprayed is irregular in shape, the grid pattern does not work so well. The rule under these conditions is to fly either along the contours or downslope. Upslope flying with a heavily loaded plan is tempting fate.

Check landmarks, hazards, and obstructions with your map before you start spraying. If adequate landmarks are lacking, flags should be put down to mark the fields or areas to be sprayed.

Facts and figures for the spray-plane pilot

Equipment facts

1. *Tanks.* Detailed information is given below.

a) *Load.* Sprays differ in weight, but for computing the maximum safe load in gallons, take 7 pounds as the weight per gallon. Divide by 7 the maximum load that the plane can safely carry; the result is the maximum number of gallons in a spray load. Allow for the weight of the tank and the dispersal equipment.

b) *Location.* The tank belongs as close as possible to the center of gravity. If it is too far from that point, the craft will be tail- or nose-heavy in flight. The tank should be fastened securely to the main structures of the fuselage. A full spray tank is heavy, and can do a lot of damage if it breaks loose.

c) *Shape.* Select a tank that is shaped to correspond with the space where it is to be attached. The bottom should be sloped so that the tank will drain completely, both while spraying and while the plane is on the ground.

d) *Material.* Of the metals, stainless steel is best, but aluminum and galvanized iron are satisfactory for most of the pesticides commonly used. Molded plastic tanks eliminate the rust and corrosion worry, and are not attacked by the usual chemical solvents. Some operators build satisfactory tanks of wood, usually plywood. They treat them inside with special paints or liquid plastics to prevent leaks, and brace them rigidly to prevent bulging. Others use removable tank liners of synthetic rubber or plastic — a different liner for each type of spray. This cuts down cleaning time and keeps one spray from contaminating another. Operators who dust as well as spray sometimes build a liquid-tight dust hopper of metal, plastic, or wood. With small changes it can also be used as a spray tank.

e) *Filler neck.* Keep it big. The best necks are large enough to allow spray liquid to be poured into the tank from a 5-gallon can or bucket without a funnel. A big neck will also give convenient access to the tank interior for cleaning. Fit the neck with a removable fine-mesh screen to catch sediment. Put it far enough down into the tank, so it will not cause splashing or flooding. The filler cap should seal tight and open easily. Attach the cap to the neck with a chain. Avoid threaded caps: they are a nuisance. Paint the word "spray" on the plane's surface near the filler neck.

f) *Air vent.* Do not put the air vent in the filler cap. Fit a pipe into the top of the tank. Let it project straight up from the tank, then curve downward. Let it project high enough so that it won't overflow from the surge of the liquid in maneuvers or rough air. Loop it down and out through the

bottom of the fuselage. A simple vent in the top of the tank may let spilled spray blow onto the windshield or into your face. Make the vent big enough to let air come in as fast as the spray goes out. Make it at least $^3/_4$ inch in diameter. If you use an emergency dumping system, you will need an even bigger air vent. Make it at least $1^1/_2$ inches in diameter.

g) *Outlet.* A sump, or low point, that can be drained is the best spot for the tank outlet to the pump. Install a short standpipe to keep sediment and solids from getting into the pump. If you have a dump valve, put the outlet on the wall of the dump-valve tube, so that sediment will settle to the bottom of the tube.

2. *Pumps.* Most operators prefer rotary-gear or centrifugal pumps. Both come in many sizes and makes. Turbine-type pumps may also be used, and in some situations gravity-feed systems are satisfactory. Piston, diaphragm, and rotary-vane units, on the other hand, have not worked satisfactorily in aerial spraying.

a) *Rotary-gear units.* There are several kinds of rotary-gear pumps. All use some combination of gears in mesh to move the liquid. Gear pumps are self-priming, and usually operate at 1,700 to 2,000 r.p.m. They work well with solutions and emulsions. Wettable-powder suspensions wear the teeth and side wall badly; they may even make the pump "seize." Since these pumps create positive pressure (as high as 500 pounds p.s.i. in some types), you will have to install a relief valve somewhere between the pressure side of the pump and the shutoff valve. Some have an adjustable relief valve incorporated in the pump body.

b) *Centrifugal units.* Since they are not of the positive-displacement type, centrifugal pumps require no relief valve. Their top pressure is seldom above 70 pounds p.s.i. They rotate at 3,000-4,000 r.p.m. Some centrifugal pumps have small impellers with wide vanes — to move high volume at low pressure. Others have large-diameter impellers with narrow vanes — to move a lower volume at higher pressure. The best pump for aerial spraying is one somewhere between these two extremes. The big advantage of centrifugal pumps is their ability to handle all kinds of spray chemicals with minimum wear. However, they are seldom self-priming. You have to mount them lower than the tank or set up some kind of priming arrangement. Also, whereas most gear pumps go either forward or backward, centrifugal pumps push the liquid in one direction only.

c) *Turbine-type units.* Turbine-type pumps, like centrifugal units, handle all sprays without undue wear. The turbine type offers somewhat higher pressures, and will pump in either direction. But it has no dry lift. You have to mount the pump lower than the tank or prime it by hand.

d) *Gravity-feed systems.* If you are handling herbicides, liquid fertilizers, or other agricultural chemicals best applied as coarse sprays, or if you are using special atomizing devices instead of standard nozzles, you may be able to skip pumps and use a gravity-feed system. The weight of the liquid in the spray tank creates the outlet pressure, but pressure and rate of flow will go down as you empty the tank. You can compensate for this and keep your output constant by installing a float chamber or variable orifice between the tank and the nozzles. Or — even simpler — vent the tank with a tube that extends through the top of the tank down through the liquid to half an inch above the bottom. The pressure of the liquid in the tank will slow the flow of air into the vacuum area created at the top of the tank as the spray goes out. This keeps the rate of discharge practically constant until the tank is emptied to below the bottom of the tube. A half-inch tube will give enough air to handle a liquid output of up to 100 g.p.m. With this negative-pressure vent system it is important that the filler cap be air tight. If a dump valve is installed, a separate vent in the top of the tank will have to be opened in conjunction with the dump valve.

3. *Material.* Nonrusting metals must be used in pumps. Brass is most common, but aluminum is recommended because it is lighter. Aluminum is used more often in centrifugal and turbine pumps than in the gear types.

Pump shafts should be brass or stainless steel. Get the mechanical type of packing seal; it lasts much longer, and needs less attention, than others.

The stuffing-box variety of packing gland gives fairly good service, but you have to tighten it when there is a leak. Do not tighten the packing nut too hard. If you do, the packing will bind the shaft and cause excessive wear.

4. *Drives.* Power sources commonly used to run a spray-plane pump include wind-driven propellers, hydraulic motors, electric motors, and the aircraft engine's accessory drive pad.

a) *Wind-driven propellers.* For a windmill assembly you need a wood or metal propeller with two to six blades. An automobile fan works well, but it is dangerous unless well reinforced.

Mount the propeller-and-pump assembly on your plane's landing gear leg or on a sturdy bracket on the side of the fuselage, or hang it under the fuselage. With the assembly in any of these places, the slipstream from the plane's propellers gives added drive to the propeller that powers the pump. The best way to fasten the propeller to the pump is to couple the propeller shaft to the pump shaft with a universal joint. If you mount the propeller directly on the pump shaft, you will need a ball-thrust bearing to carry the thrust load from the pump shaft to the pump casing. Without it, the air pressure on the pro-

peller may damage the pump. The propeller's blade pitch will determine how fast the pump rotates. Put a brake on the pump assembly. Using the brake helps lengthen the life of the pump and the packing glands.

b) *Hydraulic motors.* Hydraulic systems work well. If your plane has a hydraulic system to operate landing gear or flaps, you may be able to tie your spray pump in with it.

Generally, though, you are better off to install a separate system. Mount a hydraulic pump on an engine accessory pad, then couple a hydraulic motor to the spray pump. To complete the power system, you will need these items: hydraulic fluid reservoir (small), accumulator, pressure-relief valve, control valve, and suitable tubing.

The spray pump can be mounted entirely inside the fuselage, wherever it fits in best with the rest of the equipment.

If you pick a hydraulically driven spray-pump system, you can start and stop the hydraulic motor by using an unloader valve in the pressure line from the hydraulic pump. Run a small line from the unloader valve to an on-off valve in the cockpit, then continue the line to the hydraulic reservoir. Opening the on-off valve cuts off the hydraulic motor and stops the spray pump. You will also need a separate control valve for the spray flow. Light and powerful, this type of hydraulic system is also good for powerfeed and agitator drives in dust- or bait-hopper installations.

c) *Electric motors.* Electric-motor-driven pumps have been used for aerial spray work, but usually they are too heavy in relation to power produced.

d) *Accessory drive pad.* If you decide to use an accessory drive pad for power, you can mount the pump on the pad, or connect it up through pulleys or a flexible shaft. But these systems may have certain disadvantages. Unless you use a gear-type pump, you will probably end up with the pump mounted so high that you will have to hand-prime whenever the pump is emptied. Getting power through a flexible shaft may be difficult, and it may mean extra maintenance cost. If you have a direct-mounted or pulley-mounted system, and the pump or the lines spring a leak, there will be more fire hazard with flammable liquids than there would be if the pump were behind the firewall.

Booms, nozzles, and similar devices

A boom-and-nozzle assembly is the device most commonly used for distributing and atomizing the spray liquid. The boom is a pipe that distributes the pesticide for release from the plane. Nozzles, which atomize the liquid into spray, are mounted on the boom. The alternatives are:

1. rotating brushes or disks;
2. venturi tubes.

Whether or not you get a good spray-deposit pattern depends in large measure on the functioning of the selected device.

1. *The boom and nozzle spacing.* Location of the boom varies according to type and make of aircraft.

a) *Biplanes.* On biplanes the boom is usually mounted about a foot below the lower wing; it runs parallel to and between the spars. Or if you want to reduce drag and have a cleaner looking rig, you can install the boom in the lower wing panels, with a pipe extended down out of the wing at each nozzle location. Remember, though, that this may make it hard to repair a leaky boom (Figure 12).

Tests show that if you are spraying 1 to 10 feet above the crop in a Stearman or N3N biplane, you will get good results with a boom approximately three fourths as long as the wing span. In fact, if the boom is much longer than that, too much of the spray may get into the wingtip vortices and spoil the swath pattern.

In spacing the nozzles along the boom, put them progressively closer together as you approach the boom tips. Put a cluster of two or more at each tip. Group a few nozzles close together 3 or 4 feet to the right of the plane's center line. But on the left side of the line leave a 3- or 4-foot space without any nozzles; if you put nozzles there, the propeller slipstream will distort your pattern.

FIGURE 12. – *N3N-3 biplane spraying forest with one gallon of spray concentrate per acre.*

FIGURE 13. – *A special type of helicopter developed in the Netherlands for airspraying.*

Courtesy, Kolibrie Nederlandse Helicopter Industrie N.V. Rotterdam

b) *Low-wing monoplanes.* Boom installation and nozzle spacing on low-wing monoplanes should be the same as on biplanes.

c) *High-wing monoplanes.* On strut-braced, high-wing monoplanes the boom can be attached to the struts. It should extend outward and upward so that the outer ends are 2 feet or more below the wingtips. Some prefer to put the boom parallel to the wing, but this arrangement takes more braces. Nozzle arrangement should be similar to that described above for biplanes.

2. *Nozzles.* There are two points to be considered here:

a) *Types.* Nozzles that produce a hollow-cone spray or a flat, fan-shaped spray are most widely used for aerial spraying. The hollow-cone nozzle will produce droplets more nearly uniform in size than will the flat-spray type. It also tends to wear less. Orifice disks coated with ceramic material wear well and are desirable when you spray an abrasive mixture.

b) *Atomization.* Because the airflow buffets the spray, the degree of atomization produced by a nozzle in flight differs somewhat from the performance of the same nozzle on ground equipment, pressure on the liquid being equal. The relative angle between airflow and nozzle-output flow also is a factor. A nozzle produces smaller droplets when the orifice outlet faces forward (into the air blast) than when it faces rearward. When you set a nozzle so that it faces forward, you should direct it downward enough to keep the spray from being blown back onto the nozzle body or supporting structure. If you don't, some of the spray that collects will run off in large drops. You will be wasting spray, and the drops may injure foliage.

HELICOPTER EQUIPMENT

Load distribution

The big problem in helicopter spraying is balance. The simplest way to solve it is to install two tanks, one on each side of the fuselage directly under the rotor, and as close to the center of gravity as possible. Plan your outfit so that the spray is pumped simultaneously from each tank (Figure 13).

Atomizing apparatus

Because helicopters usually operate at such a slow flight speed, a windmill won't drive your spray pump properly. Decide on some other means of driving the pump.

A few helicopter manufacturers offer spray boom-and-nozzle assemblies for their aircraft. Some are mounted forward of the nose; others are directly in line with the rotor axis or just a few feet aft.

You can utilize the air blast from the outlet ports of the engine-cooling blower system to atomize the liquid. Direct the flow of the pesticide into the left and right outlet ports through nozzles. The effect is the same as you would get from two mist blowers mounted on the helicopter. The downwash from the rotors disperses the spray over the crop (Figures 14 and 15).

By piping the engine exhaust into the blower outlet tubes so that the air velocity past the nozzle at the outlet ports is materially increased, you get atomization approaching fog. This system gives very fine droplet sizes without using small-orifice nozzles, which clog easily, especially when used with suspensions.

FOREST SPRAYING WITH STEARMANS, N3N, AND SIMILAR PLANES

When an extensive area of several thousand acres is to be treated the application of spray usually is contracted to the commercial operator offering the lowest bid for the work. For a smaller area it may be more satisfactory to employ a reliable local operator without the formality of a contract. In either case, however, the success of the operation depends largely on careful planning. In forest spraying there are innumerable details that vary with different conditions, all of which must be anticipated for efficient execution of the program. A few of the more important ones are described below, others will become apparent as the work is planned (Yuill *et al*, 1951).

Selecting a base of operations

In selecting an airfield or landing strip, consider the distance to the area to be treated; the length, width, and distance of the runways; and the servicing facilities.

The maximum practical ferry distance between the landing strip and the area to be treated will depend

on the operating range of the aircraft and, in any case, the shorter the distance the better. Much valuable time can be lost and the cost of the operation increased by long ferry trips. In some cases it may even prove practical to construct temporary landing strips within or near such areas to reduce ferry time.

The length of runways required will depend on the type of plane to be used. For light biplanes the minimum length is approximately 800 feet. In higher altitudes, during hot, humid weather or on a soft surface, however, longer runways are necessary. Runway surfaces should be smooth enough to permit driving an automobile over them at 40 miles per hour.

Facilities for servicing the planes rapidly should be provided at the airfield. If not already available, aviation gasoline of the proper octane rating should be brought in. It may be dispensed from drums or a tank mounted on a truck. A suitable hand-operated or small engine-driven pump will greatly simplify loading the gasoline in the airplane. When a gasoline engine-driven pump is used, however, care must be taken never to permit the exhaust to be directed toward open drums. A fire extinguisher should be handy at all times. If gasoline drums or tanks contain sediment or water, the gasoline can be strained through a chamois-lined funnel while it is being pumped into the plane. The spray liquid may also be carried in drums or tanks on a truck and pumped directly into the plane.

FIGURE 14. – *Helicopter equipped with air-float type of spraying device.*

FIGURE 15. – *Spraying estate elms with boom equipped with groups of small orifice, cone-spray nozzle tips to control Dutch elm disease and foliage insects.*

Subdividing and marking of treatment areas

In large forested areas the portion to be sprayed is usually divided into units that can be treated in 1 to 3 days. If the area to be treated is broken by uninfested forest types or cultivated areas, it is divided into still smaller units. Sometimes these units can be laid out in rectangular shape; however, it is generally more practical to use ridges, water courses, roads, and other features of the terrain as the unit boundaries. Large-scale topographic maps, aerial photos, and aerial mosaics are particularly helpful in this connection. If possible, the pilot or chief pilot in charge of flying operations should be consulted when the treating units are marked out on the maps.

On many spraying operations markers are used to aid the pilot in locating the various treating units and in maintaining an accurate flight pattern. These markers may consist of white or orange flags, small wind socks, or light-colored feed sacks stuffed with brush; and they may be placed in the tops of trees or raised on sectional magnesium poles. In stands of relatively short timber the usual practice has been to climb the trees and rope or wire the markers in place. A recent interesting innovation in the west, where the height of the trees made climbing impractical, was the employment of a line-throwing shoulder gun to pass a light cord over the top of a tall tree to be used as a marker. A flag or paint bomb was then hauled up on the cord to mark the location.

On large units the markers are spaced at predetermined intervals along two opposite sides of a unit, and the pilot is instructed to apply the required number of swaths between them. Where roads or trails occur along one or two sides of a unit, a small captive meteorological balloon is used to mark each spray flight line. Here, the balloon, inflated with helium or hydrogen and attached to a light cord, is allowed to rise about 40 feet above the canopy. The pilot flies directly over the balloon, which is then moved one swath width along the boundary and another spray run is made over it. This procedure minimizes application errors, but can be employed only where continuous openings in the canopy allow the ground crew to move the balloon quickly along the boundary. For spraying plantations colored cloth panels on bamboo poles can be substituted for the balloons. Smoke flares have also been tried, but they are not recommended where they might create fire hazards.

Communications

Whenever possible some means of communication between the airfield, the treating area, and the pilot should be provided during the spraying. This should be done because, even with the most careful planning, unexpected situations that require changes in procedures always arise during actual spray operations. A radio telephone is probably the most satisfactory solution to this problem. Although most spray planes do not have radio equipment, with a proper ground set at the treating area and another at the airfield, information or instructions can be relayed as necessary. When these ground sets are not available, local telephone service may be such that a field telephone can be installed in or near the treating area.

If neither radio nor telephone is available, a system of signals may be used. One such signal system that has been satisfactory is to place a truck in an open spot visible from the air, and adjacent to or within the area being treated. When a white cloth panel is placed on the truck cab, the pilot will apply the spray as previously planned. When an orange panel is displayed, he will return to the airfield for instructions. If neither panel is shown, he will circle the area until one or the other is displayed. This system can be varied at will, but to avoid confusion the number of signals should be kept at a minimum.

On certain large spray operations in the west it has not been possible to have ground personnel in each unit or block being treated. Under such conditions there has been little need for ground-to-air communication. However, even then telephone or radio communications between headquarters and outlying landing strips have been helpful.

Pattern and altitude of flight

The flight pattern to employ in applying the spray is governed primarily by the shape and topography of the unit being treated. Where the unit is approximately rectangular and the topography is flat, the grid type of pattern is usually the most satisfactory. This pattern requires the pilot to fly in parallel lines back and forth across the unit from one side to the other, the distance between the flight lines being the same as the effective swath width of the spray plane.

Where the spray unit is irregular in shape and the terrain is steep, flights should be made along the contours or down slope. It is not safe to fly up slope, especially with a heavily loaded plane at high altitudes. It is very difficult to obtain a uniform coverage of forests in such areas. Chances for error in spacing the flight lines are greater and, since the direction of the lines changes with the topography, it is possible that the pilot will leave some spots untreated while giving others a double treatment. The chance of this happening may be so strong in some cases that it will be advisable to increase the rate of application by reducing the distance between flight lines.

With light planes it is desirable to apply the spray from an altitude of approximately 50 feet above the treetops in order to obtain the maximum swath width without excessive loss of spray by drift. For safety, however, the altitude must be increased when there are obstructions such as snags, where the terrain is rough, or when larger planes are used. With fixed-wing aircraft, spraying should never be done at less than 50 feet above the treetops. Generally the altitude and other flight procedures should be determined by a pilot, or chief pilot, who is well experienced in forest

spraying, in consultation with the supervisor of the control operation. A qualified pilot will know the performance characteristics of his plane and the limitations imposed by topography, elevation, and associated air conditions.

Observations during spraying

While the spray is being applied, one or more observers should be stationed at vantage points in or near each unit being treated. It should be their job to see that:

1. weather conditions within the area are satisfactory for spraying,
2. the pilots are maintaining the proper flight pattern and altitude.

When they find that the wind velocity (preferably measured by field anemometers) exceeds the maximum allowable for adequate control, or that the spray is not descending into the trees properly, they should either inform the man in charge of the operation or signal the pilot to stop spraying.

If possible, additional observers should be present in each unit to check on the spray coverage. They should place clean glass plates, or dyed papers (each about 4 × 4 inches), preferably in openings, at 50- to 300-foot intervals across the unit, or in as many parts of the unit as possible. They should examine the plates after the morning spraying. If the application has been uniform, they will find that all plates will carry at least a light deposit of small drops. The number of plates to use will vary with the density of the forest canopy. Where solvent-fuel oil solutions are applied, a very thin oily film or sheen will be visible on the foliage. This, too, may be used as an index of coverage, for if most of the leaves on the lower branches and on the understory plants have a visible film or spots of the spray, it is reasonably certain that the upper tree crowns have been adequately treated. The observers should locate all skips or misses in the deposit and spot them on a map for retreatment.

TABLE 10. – DETAILED LISTING BY OPERATIONAL PHASE OF A STUDY OF 178 AGRICULTURAL AVIATION ACCIDENTS, 1954

Operational phase	Number of crashes
Loading	1
Starting	3
Taxi for take-off	0
Take-off	14
Climb-out from take-off	23
En route to treat crops	4
Survey of field	1
Starting swath run	4
During swath run	21
Pull-up from swath run	28
Procedure turnaround	18
Flare-out for swath run	24
Clean-up swath	6
Maneuvering to avoid obstructions	5
Return to strip	7
Landing phase	23
Taxi after landing	5
Parking	0
Testing airplane	0
Testing-calibrating equipment	0
Training pilots	3
Ferry phase	3
Other	1

Rate of coverage

The acreage covered per hour or per day is governed by the following:

1. load capacity;
2. swath width;
3. gallons-per-acre rate and weight per gallon;
4. speed of the aircraft;
5. distance from loading field to treated area (number of trips per hour);
6. mixing and loading facilities;
7. length of runs, and whether area is flown both ways or one way;
8. the area — its size, shape, terrain, and obstructions.

A method of estimating acres treated per hour is illustrated by the following example: the effective width of swath for a given plane is 40 feet, and the average speed of flight is 90 m.p.h.

$$\frac{90 \times 5{,}280^{1} \times 40 \text{ feet}}{43{,}560 \text{ square feet.}^{2}}$$

$$= 436 \text{ acres}^{2} \text{ covered per hour}$$
$$= 7.3 \text{ acres per minute}$$

In practice the area covered may be much less than 436 acres per hour when time is taken out for loading, fueling, turning at the ends of the area, and travelling back and forth from landing field to treated plot. Consequently, if in one hour two 100-gallon loads are delivered using 4 gallons per acre, the area covered per hour is:

$$\frac{2 \times 100}{4} = 50 \text{ acres}$$

At ½, 1, 2, 3, 5, and 10 gallons per acre, respectively, the acreage covered per hour would be 400, 200, 100,

[1] 5,280 feet = 1 mile = 1.6093 kilometers.

[2] 43,560 square feet = 1 acre = 0.4047 hectare.

FIGURE 16. – *Four-engined B17 airplane spraying for gypsy moth eradication. Carries 2,000 gallons of spray mixture.*

66, 40, and 20 acres, respectively. At three loads per hour the above figures would increase by 50 percent, or double in the case of 4 loads per hour.

SPRAY PATTERN, COVERAGE, AND DEPOSIT WITH AIRCRAFT

Size of plane

A number of factors contribute to spray-coverage characteristics and deposit which have a direct bearing on efficiency and effectiveness. The first of these is the size of the plane, its wing expanse and the altitude at which it flies. Small planes and low flying decreases swath width while the reverse condition increases it. For example, cubs normally disperse an effective swath of 32 to 42 feet for crops at an altitude of 2 to 10 feet; or 75 feet when flying 30 to 60 feet above the vegetation, as in spraying forests. In the case of Stearman biplanes, the normal effective swath width for the 2- to 10-foot flight level is considered to be essentially the same as the wing spread but this can be altered somewhat by the engine's power, the length of the spray boom and the nozzle arrangement. When spraying forests, Stearmans usually fly 100- to 130-foot swaths. The DC3 and B17 multimotored planes fly 500-foot swaths over forests at a flight level of 150 feet above the canopy at a speed of 150 m.p.h. (Figure 16).

Atomization

The degree of atomization is often the most important factor concerned in pest control by aircraft. It influences swath width and pattern, distribution, coverage, deposit, gallonage required per acre, and spray drift. The important factors responsible for a given degree of atomization are:

1. the nozzles (their construction, orifice size, position, and direction of discharge);
2. pressure;
3. aircraft speed;
4. air velocity and volume of the propeller slip stream and the relative proportion of spray that is released in the slip stream;
5. the composition and viscosity of the mixture.

When releasing the spray at 50 feet or more above forests for defoliators such as sawflies, tent caterpillars, gypsy moths, tussock moths, and spruce budworms a drop pattern with a mass average diameter of 150 microns seems to be about right. If the drops are too small, the deposit will be light and much of the spray will be carried up into the upper air currents and drift away from the area being treated. For crop spraying at the 2- 5- 10- and 25-foot levels a mass average drop diameter of 60, 70, 75 and 100 microns appears to be about right. At the 2- to 10-foot level there is considerable air turbulence in the wake of the plane's passage and slip stream. This turbulence is sufficient to deposit droplets of smaller size than for the 25-foot or greater

TABLE 11. – SHOWING EFFECT OF NOZZLE SIZE, NOZZLE POSITION, AND AIRCRAFT SPEED ON ATOMIZATION OF FIVE WHIRLJET NOZZLES AT 40 P.S.I. NOZZLE PRESSURE[a]

Speed of aircraft (m.p.h.)	Nozzle number		Diameter of orifice, in inches	g.p.m. delivery	Mass aver. diameter in microns, with nozzle pointing		
	Conn. ♀	Conn. ♂			forward	down	aft
60	A1	B1	1/16 (.062)	0.2	110	116	128
	A2	B2	5/64 (.078)	0.4	115	135	160
	A3	B3	3/32 (.093)	0.6	136	165	175
	A5	B5	1/8 (.125)	1.0	152	180	238
	A10	B10	3/32 (.187)	2.0	170	210	276
80	A1	B1	1/16 (.062)	0.2	90	130	158
	A2	B2	5/64 (.078)	0.4	98	138	175
	A3	B3	3/32 (.093)	0.6	110	150	190
	A5	B5	1/8 (.125)	1.0	120	160	225
	A10	B10	3/32 (.187)	2.0	150	210	260
100	A1	A1	1/16 (.062)	0.2	78	100	145
	A2	A2	5/64 (.078)	0.4	88	114	155
	A3	B3	3/32 (.093)	0.6	100	125	165
	A5	B5	1/8 (.125)	1.0	114	152	182
	A10	B10	3/32 (.187)	2.0	130	182	218

[a] Pump pressure is usually 5 to 10 p.s.i. greater than nozzle pressure. Check valves usually increase pressure about 5 p.s.i.

level, where the effect of turbulence is lost. Also, drift is minimized at the lower flight level. Air turbulence greatly improves under surface coverage and penetration of the vegetation. Hence, with medium fine atomization and low flight it is possible to control many diseases and insects (aphids, mites, etc.) that could not be as effectively controlled with larger drops delivered at higher flight levels.

It remains to be shown precisely what degree of atomization results at given air speeds when the nozzles are placed in given positions in relation to the plane's line of travel. Table 11 gives the degree of atomization from 5 sizes of whirljet nozzles on a biplane traveling at 60, 80, and 100 m.p.h.

In general, most other types of cone nozzles with the same included angle and output give about the same degree of atomization. Flat or fanshaped spray nozzles do not atomize quite as finely as the cone types.

The finest atomization is produced with the nozzles pointing forward but this may cause some of the spray to collect on the structures of the airplane. If nozzles point to the rear the atomization is coarse. Therefore, it is usually best to point the nozzles down or slightly forward. Small nozzle orifices, including oil burner nozzle tips, can be used for fine atomization when applying solutions and emulsions but not for mixtures containing wettable powders which require an orifice of $^3/_{32}$ inch or greater to avoid clogging. The use of small orifices requires a large number of nozzle tips or nozzle clusters to deliver the desired output. When spraying through finely atomizing nozzles it is important to have a good 30- to 40-mesh screen between the pump and the nozzles.

Nozzles that deliver the coarsest spray and the most uniform drop size have consisted simply of short hollow tubes pointing aft of the boom.

Increasing or decreasing the pressure increases or decreases the atomization to a lesser degree than a corresponding change in size of orifice or speed of aircraft.

Gear pumps can develop considerable pressure but high pressure requires considerable power which may limit the use of air-driven pumps where a high spray output is required.

Increasing or decreasing the speed of the aircraft has a great effect on degree of atomization like increasing or decreasing the air velocity of a mist blower. Some increase or decrease in atomization can be made by changing the viscosity and composition of the spray mixture.

Swath widths should be conservatively estimated and generally lapped in order that sufficient material be deposited over the entire sprayed area. The number of nozzles and their size will be governed by the desired application rate, swath width, and speed of flight. Some spray delivery rates in gallons per minute for various application rates for three swath rates and three flight speeds are listed in Table 13. Table 14 on page 148 gives the same sort of information for larger aircraft.

Table 12. – Number of Nozzles Required for Given Spray Delivery Rates [a]

Rate, in g.p.m. per nozzle	Number of nozzles required for the following deliveries							
	5	7.5	10	15	20	25	30	40
0.1	50	75	100	150	200	250	300	400
0.15	33	50	67	100	134	167	200	267
0.2	25	38	50	75	100	225	150	200
0.3	17	25	33	50	67	84	100	134
0.4	12.5	19	25	38	50	113	75	100
0.6	8.3	12.5	17	25	33	42	50	67
0.75	6.7	10.	13.4	20	27	33.4	40	54
0.8	6.25	9.4	12.5	18.8	25	31.3	37.5	50
1.0	5.	7.5	10	15	20	25	30	40
1.5	3.3	5.0	6.7	10	13.4	16.7	20	26.7
2.0	2.5	2.5	5.	7.5	10	12.5	15	20
2.5	2.	3.	4.	6.	8.	10.	12.	16.
3.0	–	–	–	5.	7.	8.	10.	13.4

[a] Pump capacity should be 20 percent greater than the maximum total nozzle output required.

Table 13. – Spray Delivery Requirements in Gallons per Minute for Various Application Rates, Speeds, and Swath Widths

Flight speed, in miles per hour	Gallons, per acre	Required spray delivery, in gallons per minute		
		30 ft. swath	40 ft. swath	50 ft. swath
60	½	1.8	2.4	3.0
60	1	3.6	4.8	6.1
60	2	7.3	9.7	12.1
60	3	10.9	14.5	18.2
60	4	14.5	19.4	24.2
70	½	2.1	2.8	3.5
70	1	4.2	5.7	7.1
70	2	8.5	11.3	14.1
70	3	12.7	17.0	21.2
70	4	17.0	22.6	28.3
80	½	2.4	3.2	4.0
80	1	4.8	6.5	8.1
80	2	9.7	12.9	16.2
80	3	14.5	19.4	24.2
80	4	19.4	25.9	32.3

Calibration

The calibration problem has been well considered by Yuill, Eaton, and Isler (1951) as follows: "The importance of proper performance in spray equipment cannot be overemphasized. Unfortunately the methods required

Table 14. – Spray Delivery Requirements (in g.p.m.) for Various Gallonage Rates, Speeds, and Swath Widths, Particularly Applicable to Biplanes and Various Types Larger than Piper Cubs

Flight speed, m.p.h.	Gallons per acre	Required spray delivery in gallons per minute										
		20 ft. swath	25 ft. swath	30 ft. swath	40 ft. swath	50 ft. swath	60 ft. swath	70 ft. swath	ft. 80 swath	ft. 100 swath	ft. 125 swath	150 ft. swath
60	0.5	1.2	1.5	1.8	2.4	3.0	3.6	4.2	4.8	6.0	7.5	9.0
60	1	2.4	3.0	3.6	4.8	6.1	7.2	8.4	9.6	12.0	15.0	18.0
60	2	4.8	6.1	7.3	9.7	12.1	14.4	16.8	19.2	24.0	30.0	36.0
60	3	7.2	9.1	10.9	14.5	18.2	21.6	25.2	28.8	36.0	45.0	54.0
60	4	9.6	12.2	14.5	19.4	24.2	18.8	33.6	38.4	48.0	60.0	72.0
60	5	12.0	15.0	18.0	24.0	30.0	36.0	42.0	48.0	60.0	75.0	90.0
60	7.5	18.0	22.5	27.0	36.0	45.0	48.0	63.0	72.0	90.0	113.0	135.0
60	10	24.0	30.0	36.0	48.0	61.0	72.0	84.0	96.0	120.0	150.0	180.0
60	12	28.8	36.1	43.3	57.7	73.0	86.0	101.0	115.0	144.0	180.0	216.0
60	15	36.0	45.0	54.0	72.0	91.0	108.0	126.0	144.0	180.0	225.0	270.0
60	20	48.0	60.0	72.0	96.0	122.0	144.0	168.0	192.0	240.0	300.0	360.0
70	0.5	1.4	1.75	2.1	2.8	3.5	4.2	4.9	5.6	7.0	8.75	10.5
70	1	2.8	3.5	4.2	5.7	7.1	8.4	9.8	11.2	14.0	17.5	21.0
70	2	5.6	7.0	8.5	11.3	14.1	16.8	19.6	22.4	28.0	35.0	42.0
70	3	8.4	10.5	12.7	17.0	21.2	52.2	29.4	33.6	42.0	53.0	63.0
70	4	11.2	14.0	17.0	22.6	28.3	33.4	39.2	44.8	56.0	70.0	84.0
70	5	14.0	17.5	21.0	28.0	35.0	42.0	49.0	56.0	70.0	88.0	105.0
70	7.5	21.0	26.3	31.5	42.0	53.0	63.0	74.0	84.0	105.0	132.0	158.0
70	10	28.0	35.0	42.0	56.0	70.0	84.0	98.0	112.0	140.0	176.0	210.0
70	12	33.6	42.0	50.5	67.0	84.0	101.0	118.0	134.0	168.0	211.0	252.0
70	15	43.0	53.0	63.0	84.0	106.0	126.0	148.0	168.0	210.0	264.0	316.0
70	20	57.0	71.0	85.0	113.0	142.0	168.0	201.0	226.0	284.0	355.0	426.0
80	0.5	1.6	2.0	2.4	3.2	4.0	4.8	5.6	6.4	8.0	10.0	12.0
80	1	3.3	4.05	4.8	6.5	8.1	9.6	11.3	13.0	16.2	20.25	24.3
80	2	6.5	8.1	9.7	12.9	16.2	19.4	22.6	25.8	32.4	40.5	48.6
80	3	9.6	12.1	14.5	19.4	24.2	29.0	34.0	38.8	48.4	60.5	72.6
80	4	13.0	16.2	19.4	25.9	32.3	38.8	45.3	51.8	64.6	80.8	97.0
80	5	16.1	20.2	24.2	32.3	40.4	48.4	56.6	63.6	80.8	101.0	121.0
80	7.5	24.1	30.3	36.3	48.4	60.6	72.6	84.9	94.4	121.0	152.0	182.0
80	10	32.2	40.4	48.4	64.6	80.8	96.8	113.2	127.2	161.6	202.0	242.0
80	12	38.7	48.5	58.1	76.5	97.0	116.0	136.0	153.0	194.0	243.0	291.0
80	15	48.3	60.6	72.6	96.9	121.0	145.0	169.0	191.0	242.0	303.0	363.0
80	20	64.4	80.8	96.8	129.2	161.6	193.6	226.4	254.4	323.0	404.0	484.0
100	0.5	2.0	2.55	3.05	4.1	5.1	6.1	7.15	8.2	10.2	12.8	15.3
100	1	4.1	5.1	6.1	8.2	10.2	12.2	14.3	16.4	20.4	25.5	30.6
100	2	8.2	10.2	12.2	16.4	20.4	24.4	28.6	32.8	40.8	51.0	61.2
100	3	12.3	15.3	18.3	24.6	30.6	36.6	42.9	49.2	61.2	76.5	91.8
100	4	16.4	20.4	24.4	32.8	40.8	48.8	57.2	65.6	81.6	102.0	122.4
100	5	20.5	25.5	30.5	41.0	51.0	61.0	71.5	82.0	102.0	127.5	153.0
100	7.5	30.3	38.3	45.8	61.5	76.5	91.5	107.2	123.0	153.0	191.0	230.0
100	10	41.0	51.0	61.0	82.0	102.0	122.0	143.0	164.0	204.0	255.0	306.0
100	12	49.2	61.2	73.2	98.4	122.4	146.4	171.6	196.8	244.8	306.0	367.0
100	15	61.5	76.5	91.5	123.0	153.0	183.0	214.5	246.0	306.0	383.0	459.0
100	20	82.0	102.0	122.0	164.0	204.0	244.0	286.0	328.0	408.0	510.0	612.0

for precise evaluations of equipment are too involved for use in the field. However, the tests described below will give a rough estimate of performance and should bring out any serious inadequacies.

"The flow rate, or output, can be determined as follows:

1. Put a measured amount of spray liquid in the tank.
2. Have the pilot turn the spray on for a timed interval (30 to 60 seconds) while in straight and level flight at the air speed to be used in the spraying operation.
3. When the plane lands, drain and measure the liquid remaining in the tank.
4. Compute the flow rate in gallons per minute.

An alternate method is as follows:

1. Fill the tank to a definite level such as a specific point in the filler neck.
2. Fly the plane as described above.
3. After landing, spot the plane in exactly the same location used when filling the tank and measure the amount required to refill to exactly the same level.
4. Compute the flow rate as above.

Two or three replicate flights should be made, and the results for any one spray mixture should not vary by more than 3 percent. Fuel oil alone can be used for determining the flow rates of DDT-fuel oil solutions. For emulsions and suspensions the mixed sprays should be used. The flow rate required can be computed by the formula

$$F = \frac{S\,W\,D}{495}$$

when F = flow rate (output) in gallons per minute;
S = speed of the plane in miles per hour;
W = width of effective swath (not total swath) in feet;
D = dosage to be applied in gallons of liquid spray per acre.

Any delivery rates in gallons per minute may also be computed as follows:

$$D = \frac{R\,S\,W}{495}$$

when D = delivery required, in gallons per minute;
R = application rate, in gallons per acre;
S = flight speed, in miles per hour;
W = swath width treated, in feet.

The swath width of planes equipped with a full-wingspan-boom can be estimated roughly by multiplying the wingspan by 3.5 to 4. However, this is only an approximation. It applies only to planes in which spray is released over the full wingspan, and from a height above the trees greater than the wingspan."

Silvicide Equipment and Methods for use along Power Lines and in Forest Management

Selective chemicals enable foresters to thin, release, and favor one species over another. The concentrated spray method of application, from the ground or from the air, will enable the forester to cover both large and small areas quickly and cheaply. For example, as little as 1 to 3 quarts of 2, 4, 5-T ester can be used in 2 to 3 gallons of final spray per acre effectively to release conifers from aggressive, competing hardwoods of any size.

The use of silvicides in forestry is only in its infancy. Nevertheless, the following uses have been demonstrated.

1. the control of undesirable plant and tree species, as in the preparation of area for planting;
2. releasing coniferous seedlings and trees (both natural and planted) that are being crowded out by undergrowth, hardwood sprouts, or overstory;
3. control of brush along power lines, trails, and roadways through the forests.

For any efficient silvicidal job it is necessary to evaluate the requirements including that for application equipment, methods, and cost. From this evaluation must come the answers to such questions as: Do we want all of the growth cleared or are we satisfied with thinning it out a bit? Is it composed of dense, tall brush and trees or is there a clump here and there? What species are involved or predominant? Is the area readily accessible to spray equipment or will it require some special effort to get through and make the application? What are the hazards — stumps, rocks, terrain, drift, etc.? Size of area is important too, because it costs more per unit area to treat small areas than large ones.

Cost is the essential factor of any silvicidal program. To reduce cost and increase speed and ease of coverage we must look to four categories as follows:

1. cheaper and more phytotoxic, selective chemicals;
2. effective methods for using less total chemical per acre;
3. methods for using less diluent and total spray volume per acre;
4. cheaper, lighter, and more mobile spray equipment.

In all of these categories, except the first one, we must depend on equipment and application methods. An example of selecting the cheapest effective chemical for control of willows is the use of 2, 4-D amine (which costs U.S.$2.70 per gallon) instead of 2, 4, 5-T (which costs U.S.$9.00 to U.S.$10.00 per gallon).

Foliage applications of one to two quarts 2, 4, 5-T per acre costs about U.S.$2.25 to U.S.$5.00 per acre for the chemicals alone. Cost of labor and equipment will vary according to conditions referred to later.

Kinds of treatment

Application of silvicides may be classified as to foliage, basal stem, and stump or stubble. Foliage application is the quickest and best adapted way to treat for the first time over to convert growth to a relatively non-woody plant area. This method is limited to seasonal operation.

Basal stem treatment

Basal stem treatment is particularly useful to control sparse infestations inaccessible to other spray equipment; and for treating stems that survive foliage applications. Treatment can be made any time, preferably during the dormant period without chance of injury to sensitive crops. This permits use of manpower during the off-season. Relatively inexpensive equipment is required. However, it is not as economical or as widely applicable as foliar sprays and stems larger than 2 inches in diameter are difficult to kill. A high labor cost is involved because each stem must be thoroughly wet on all sides at the ground line. To obtain desired results it is important to apply sufficient liquid to assure physical run-down outside the stem to the root crown, bud, or transition zone of the plant. Knapsack or round back compressed air sprayers are more often used to apply the chemicals. However, a useful light power unit consists of a 4 h.p. gas engine, ½ inch gear pump, and two lines of light hose with a suitable nozzle, gun and shut-off valve attached to each line of hose. The chemicals are used at 5 times the concentration of dilute sprays i.e., 16 pounds 2, 4, 5-T acid or more per 100 gallons of No. 2 fuel or diesel oil, or 1 pint in 2½ gallons of oil. To aid in marking, up to 60 percent of the oil in the mixture can be supplied from strained black carbon waste oils of filling stations and garages. White strings may also be used to lay out spraying lanes of 40 to 60 feet in width to help guide the spray men.

Stumps should be thoroughly wetted at time of cutting to reduce sprouting. This practice is relatively inexpensive from a labor standpoint, especially when stump diameter is greater than two inches. Usually one man treats the stumps behind a regular cutting crew. Ammate may be applied as crystals at the rate of 2 ounces per 6 inches of diameter, or thoroughly wetting with concentrate solution of 4 to 6 pounds per gallon of water. The 2, 4, 5-T esters are used at 16 to 20 pounds per 100 gallons of oil (or 1 pint per 2.5 gallons of diesel oil) to wet the stump thoroughly as for the basal stem application.

Foliage sprays

The 2, 4-D weed killers will control certain species as willow, alder, sumac, elderberry, brambles, raspberry, blackberry, and other easier-to-control woody plants. However, it is not sufficiently effective against most dominant hardwoods like oak, ash, hickory, persimmon, and maple. For these and most other resistant woody species like osage orange, 2, 4, 5-T is more effective than 2, 4-D. A common mixture is one containing 2 lbs. of 2, 4, 5-T and 2 lbs. of 2, 4-D acid equivalent per gallon. Water is a cheaper diluent for it than oil. For the dilute or full dilution sprays, 3 to 6 quarts of 2, 4-D — 2, 4, 5-T mixture is added to each 100 gallons of water for foliage application.

"Silvex" or "Kuron"[3] is more effective against a few species like scrub oak than 2, 4, 5-T and Amino triazole is more effective than other materials for thistles and poison ivy. "Ammate" is applied to foliage at the rate of 75 pounds per 100 gallons of water. Thorough wetting with a spreader-sticker is important. Compared to most other silvicides it is more expensive and is rougher on equipment, particularly copper and brass gears and pipes. For semi-concentrate application, concentrations up to 8X, or 6 pounds per gallon, can be prepared. Ammate is more nearly a "one shot" treatment, making retreatment unnecessary for several years because it effects an 80 percent or better root kill of mixed species. Being nonvolatile, there is less danger from drift.

Equipment and application methods

Conventional power equipment

The conventional equipment ordinarily consists of a conventional pistol type hydraulic sprayer (as Hardie, Bean, Iron Age, Myer, etc.) with $^3/_4$ inch high pressure hoze. Nozzle sizes fit the pump capacity. The 15 g.p.m. pumps can use the $^3/_{16}$ inch orifice but the $^1/_4$, $^{15}/_{64}$, and $^5/_{16}$ inch orifice will require the 35 and 60 g.p.m. pumps. This necessitates a big, heavy outfit.

Knapsack sprayers

The 2, 4, 5-T, "Silvex," Amino triazole, Dalapon, and other hormone types are very effective when applied in the form of concentrated sprays. Knapsack sprayers or compressed-air back sprayers may be effectively used to apply 4 to 10 gallons of finished spray concentrate per acre. This gives no spray drip and run-off. The low gallonage used enables each man to cover 3 to 6 acres per day. This system is also very economical for spot spraying and for retreatment of old sprayed areas. It is limited by the fact that it cannot reach growth higher than 12 to 15 feet. A 6- to 8-foot aluminum extension rod is required for high growth. A most important item is a suitable low gallonage atomizing nozzle to provide suitable atomization without delivering too much spray material. The nozzles should be 2.5 to 6 g.p.h. cone type, oil burner nozzles, such as Monarch F80 series,[4] Nos. 6.00, 7.00, and 8.00, or the equivalent in other brands. The round tank, 2 to 3 gallon-compressed air back sprayers costing about U.S.$8.00 each are most economical.

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[3] "Silvex" and "Kuron" are trade names for 2 (2, 4, 5-Trichlorophenoxy) propionic acid.

[4] Monarch Works Mfg. Co., cor. Salmon and Westmoreland Sts., Phila., Pa.

Mist blowers

For applying herbicides and silvicides the mist blower is the most fantastic plant killer known. For most brush and forest management operations mist blowers in the 5 to 12 h.p. sizes are most applicable. These units are mounted on a four wheel drive power wagon, jeep, regular tractor, or a crawler type tractor with bulldozer blade mounted in front. The relative abundance of stumps, trees, rocks and ditches determine the kind of carriage vehicle. The caterpillar or crawler type tractor is best suited for extremely difficult conditions.

On tractors, the mist sprayer is mounted on a sturdy rack at the rear of the tractor so that the air outlet points at right angles to the line of travel. The outlet should point slightly above the top of the growth to be treated. The shut-off valve should be close enough to the driver's seat for him easily to turn it on and off. For most of our work we used 12 to 20 pounds pressure and a No. 1 or No. 2, $^1/_8$ inch Conn. Whirljet nozzle.[5] If the air velocity was greater than 115 m.p.h. the nozzle was pointed in the same direction as the air blast. In swath spraying to cover an entire area the mist blower treated 30-foot swaths from two opposite sides by spraying while going down on one side of the strip and coming back on the other side. About 30 to 40 acres could be treated per day on favorable terrain. None of the spray should be allowed to drift onto useful plants and crops.

Knapsack mist blower

Where drift hazards can be avoided, the 2 h.p. knapsack mist blower can be a useful tool for spraying brush up to 30 feet in height using 2 to 4 gallons of finished spray concentrate per acre of solid growth. Less material is needed for spot treatments. A drop size range of 50 to 75 microns mass average diameter is best for most purposes. A good knapsack mist blower can treat 10 to 15 acres of brush per day. It is also useful for spot spraying and retreatments. A good spray team consists of two men with two blowers to do the spraying and one man to refill and service the two sprayers.

Helicopters

The helicopter is being used successfully to treat many miles of rights-of-ways along power lines using 3 to 6 quarts of 2, 4, 5-T or 2, 4, 5-T propionic acid per acre in 3 to 5 gallons of No. 2 fuel oil per acre. Its use in many areas is prevented by the hazards involved, such as drift and flying risk. The helicopter should not be flown directly over power lines. Therefore, one objective is to fly parallel to the line and throw a coarse spray of about 200 microns drop diameter in from the edge of the right-of-way towards the center.

Where drift is not a serious risk the helicopter is an excellent tool for applying silvicides to release conifers from competing hardwoods or to kill the growth in areas that are to be planted to conifers or other trees. Large, tall trees are killed just as easily as low-growing trees, brush and sprouts.

Airplanes

Airplanes may be used in much the same way as helicopters except that larger areas are required and the drift hazard is far greater.

Terms

Definition of particle size and terms relating to concentrated and dilute spray, aerosol, smoke and dust application

There has been considerable confusion in defining particle size and in the use of terms relating to concentrated and dilute spray, aerosol, smoke, and dust application. Incorrect interpretation and lack of understanding of the fundamentals involved have resulted in much needless waste of time, money, and lack of maximum effective results. It seems timely to suggest definitions for some of the terminology in this particular field of disperse systems and to indicate their proper use.

Particle size

Thorough understanding of the meaning of particle or drop size and proper methods of recovering and measuring particle samples would help remove the confusion associated with some of the terms that follow. The term particle size has had several meanings, often misconstrued, depending on whether one refers to radius, diameter, volume ($4.2R^3$), surface area ($3.14d^2$), or density. In stating actual size of round droplets one should make clear whether radius or diameter is meant, because a droplet with radius of 50 microns[6], is 8 times larger in terms of volume than one with a diameter of 50 microns and 64 times larger than one of 25 microns diameter. A particle of given diameter or volume with a density of 5 is $2\frac{1}{2}$ times as heavy as one having a density of 2, and particles of the same size or density may expose very different surface areas. The term *average diameter* (or average radius) should be qualified, since average diameter can be considered as either a *mass average diameter*, *numerical average diameter*, or *mass median diameter*. If all droplets were of the same size their average numerical, mass, and median diameters would be identical.

The *mass median diameter* is the drop diameter that satisfies the condition that half the spray volume is of drops larger, and half is of drops smaller, than it.

[5] Spraying Systems Co., Bellwood (Chicago), Illinois.

[6] A *micron* is 1/1,000 millimeter.

Mass average diameter is the diameter of the drop of average volume. A typical spray pattern having a numerical average drop diameter of 40 microns, also gave a mass average drop diameter of 52 microns and a mass median drop diameter of 56 microns. Over half of the drops were less than 31 microns in diameter.

Mass average diameter, sometimes incorrectly called *mass median diameter*, is the diameter of the drop whose volume is obtained by dividing the volume of spray in the sample by the total number of drops. The diameter of a sphere of this volume is then found, by the equation:

$$D \text{ (diameter in microns)} = 2 \sqrt[3]{\frac{\text{volume (cubic microns)}}{4.2}}$$

Numerical average diameter is found by adding all the drop diameters and dividing by the number of drops. It is always less than the mass average diameter, and most of the volume of the spray pattern is in drops having diameters larger than the numerical average. The volume of a sphere of this diameter multiplied by the total number of drops does not equal the total volume of spray.

In any discussion of particle size the method of obtaining particle samples of spray or dust should be adequately stated or understood by both writer and reader. The importance of indicating the sampling method is illustrated by the fact that when the mass average diameter is greater than approximately 75 microns, nearly complete droplet patterns can be recovered out-of-doors on foliage and microscope slides; but when the mass average drop diameter is 10 microns or less, over 95 percent of the drops are too small to deposit on or impinge upon foliage, insects, and slides out-of-doors, thus making it necessary to trap drop samples in the air.

Size of dust particles. The size of dust particles quoted on a package or container refers to the diameter of individual particles, and is not related to the size of dust particles deposited on plants and other objects. This deposit consists mostly of large particle " groups ", or " glomerates " of many particles, since most extremely fine individual dust particles do not ordinarily deposit satisfactorily on plants and insects out-of-doors.

Deposit as related to contact effect and stomach poison effect. A great deal of confusion has arisen because of a lack of understanding of the relationship of particle size to contact and stomach poison effect. Many assume that an aerosol or spray that is too fine to leave a deposit can be an effective contact poison. Excepting fumigants, they could not be an effective contact toxicant because no particles can kill insects without being deposited on them or on the plants. Whether contact or stomach poison *effect* is considered, effectiveness is directly dependent on the quantity and distribution of the deposit. *Oil-coated dust* and *air-mixed-oil-coated dust* are terms that should convey two quite different meanings. An *oil-coated dust* is made before application in a mixing device, such as a ball mill. It may contain from 2 to 12 percent oil by weight, and is applied in the usual manner by conventional dusters. Most materials containing more than 8 to 12 percent oil or other liquid cannot be dusted. *Air-mixed-oil-coated* dust is a new application method in which special spray-dust equipment simultaneously applies and mixes atomized dust and finely atomized oil. For dust to deposit and adhere most effectively it should be coated with 20 percent or more of oil by weight. Greatest deposit and adherence seems to occur when all of the dust is coated with about 50 percent oil by weight. *Spray-dust*, and " *wet-dust* " have the same meaning as the above term, except that it also includes similar application of water and sprays other than oils.

Definition of spray methods

The terms *dilute*, *ordinary*, or *conventional spray method* refer to ground applications of 75 to 1,000 gallons per acre of mixtures of low insecticidal concentration. In the so-called mist-spraying of dilute spray with air carrier, most of the spray volume is in drops of 150 to 1,500 microns diameter. In solid stream spraying the drops are 1,000 to 3,000 microns diameter, and water is the carrier when spraying living plants. The volume of spray is sufficient to wet foliage very noticeably, often to the extent of considerable drippage and run-off. Pressure is applied directly to the liquid, as compressed air in the tank of a knapsack sprayer, or hydraulic pressure on the liquid between pump and nozzle in a high pressure power sprayer.

Concentrate application has these necessary characteristics:

1. a low volume (¼ to 15 gallons) per acre, or per unit area;
2. insecticide concentration many times that of any dilute spray mixture of the same insecticide;
3. fine atomization compared to that for dilute sprays; with most of the spray volume in drops less than 300 microns diameter.

The spray can be a *solution*, *emulsion*, or *suspension*. Concentrated sprays can be applied with several types of equipment. Atomization can be accomplished:

1. mechanically, with direct pressure through special conventional nozzles, compressed air, air velocity (as from a blower or the forward speed or propeller blast of aircraft), centrifugal devices;
2. liquefied gas;
3. steam or thermal generated smokes, etc.

Atomized spray, *atomized oil*, *vapor-spray* and *vapor-dust* are poorly adapted terms used to denote concentrated spray application. Actually, any spray mixture

is atomized upon application whether dilute or concentrated. *Vapor dust* and *vapor spray* are improper hybrid expressions.

Semi-concentrate sprays are those having an insecticidal concentration of 2 to 7 times that of regular conventional sprays. This often requires an application of 15 to 35 gallons per acre for crops, and 30 to 70 gallons per acre for fruits.

X-concentration means the number of times the concentration of the mixture is greater than the regular conventional spray. For example, the conventional spray concentration is X1. Mixtures that are 5, 10, 20, etc., times its concentration are known, as X5, X10, X20, etc., concentration.

Aerosols

The word "aerosol" is one of the most incorrectly used terms. Relatively few people have used it correctly or understood its meaning. Physical chemists prefer to designate aerosols as air suspensions of extremely fine, dry, or liquid particles of almost colloidal fineness that are considerably less than 4 microns in diameter and which may remain suspended in the air for hours or even days. Clouds of extremely fine individual dust or smoke particles are typical aerosols. They are not vapors or gases and ordinarily do not pass through the breathing pores of insects. Aerosols will eventually settle out in calm air of a convection-free room or container, but do not deposit out-of-doors to any appreciable extent on plants, insects, and other objects. Therefore, under ordinary conditions true aerosols are not effective field insecticides. Highly successful field control with "liquefied gas" aerosols are reported, but these are not true aerosols. Most of the insect mortality is due to that portion of the atomized concentrate which is in droplet sizes exceeding 15 microns diameter. Aerosols can be made from liquids by mechanical atomization, condensation of thermally generated vapors into "smokes", and by liquefied gas propulsion. In discussions of dusts and atomized sprays, specifications should be made of the particle size or degree of fineness. Small droplets originally above aerosol size sometimes become aerosols when allowed to drift in the air long enough for volatile fractions to evaporate.

Smokes are true aerosols whether the particles are liquid or dry. The particles or droplets are separated. Most of them are one micron or less in diameter in the case of screening smokes, but may be larger in the case of certain other less dense smoke clouds. Under certain conditions the size of smoke particles can be greatly increased but as soon as the particles grow beyond aerosol size they are no longer smokes or aerosols and therefore do not appear or behave like smokes.

Vapor is a gasified liquid or solid mixed with air and may be capable of condensation into drops or larger particles, often producing a smoke-like appearance, depending on fineness.

Concentrate applicators

Ground equipment

Many sizes and types of equipment may be used for applying concentrates when equipped with a suitable atomizing nozzle. These include hand atomizers, knapsack sprayers, liquefied gas spray dispersing apparatus, thermal generators, mist blowers, and power driven non-blower type, low gallonage sprayers.

A *liquefied gas sprayer* is an apparatus which disperses a mixture of liquid gas (as freon, methyl cloride, CO_2, etc.) and pesticide, or some other chemical to be sprayed as a finely atomized concentrate. At ordinary room or spraying temperatures the liquid gas in the mixture volatilizes and thus generates its own pressure for atomizing and dispersing the spray. The gas output that carries the mist is more nearly comparable in volume with that from small orifice compressed air nozzles and therefore it cannot project the mist great distances like the air blast of mist blowers.

Thermal generators (mist, fog, or aerosol). Thermal generators are applicators that utilize heat to atomize liquid concentrate sprays. They may disperse a fine mist an or aerosol fog. They may or may not have a blower (fan) to drive the droplets to some distance from it. With a blower, they may operate with a breeze, against a contrary wind, or in the absence of any noticeable air movement. When the unit operates with a fan it is essentially a mist blower that uses heat to assist in atomizing the liquid. Either steam, hot air, hot volatized oil, or hot metal rings or hot exhaust pipes are employed to atomize the spray liquid.

Mist blowers. A mist blower is a power driven ground machine that disperses highly concentrated sprays in finely atomized (10 to 150 microns) form at low gallonages per acre (or per unit area) with air as the principal carrier instead of water or other liquid carrier.

Low gallonage power concentrate sprayers may be operated without a blower for applying insecticides and herbicides to low growing crops, weeds, and brush. The spray liquid is pumped through low gallonage conventional type (as oil burner) cone or flat spray nozzles at 20 to 100 pounds pressure. This type of apparatus is cheaper, lighter, and more simple than blower type apparatus, but has the disadvantage of producing coarser drops, lack of driving power to carry the mist, and its effectiveness is limited to low-growing plants.

Aerial equipment

Compressed air power atomizers use a compressor to develop air pressure for delivering both air and liquid through atomizing nozzles at 10 to 50 pounds pressure for applying concentrates to low-growing plants.

A *helicopter mist sprayer* is an airborne mist blower for applying concentrated sprays in which a large volume of low velocity air from large propellers or rotary wings mounted above the aircraft tends to drive the spray mist downward. The spray may be atomized by oil-burner type nozzles with pressures above 25 pounds per square inch (p. s. i.) developed by a pump driven by the helicopter's motor; or it may be atomized by high air velocity from a fan.

An *airplane mist sprayer* is a fixed winged, airborne concentrate applicator, which utilizes the speed of the aircraft to help atomize the spray, and which may or may not utilize pump pressure or the air blast from the propeller of the aircraft's engine to atomize the spray. Power for driving the pump is usually derived from a small airdriven propeller.

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Stacked lumber in a yard at Seattle, Washington. The Fifth World Forestry Congress will be held on the Campus of the University of Washington at Seattle. Previous World Forestry Congresses were held at Rome, Italy, 1926; Budapest, Hungary, 1936; Helsinki, Finland, 1949; and Dehra Dun, India, 1954.

Courtesy K. S. Brown, Seattle

Forest Industries Planning in Indonesia

J. A. von Monroy
FAO Technical Assistance Officer[1]

Indonesia was one of the first countries of Southeast Asia to apply for long-term aid, under the United Nations Technical Assistance Program, in the preparation and implementation of an integrated forest industries development program. The initial request was for a thorough survey and analysis of the forest industries situation and then the formulation of a development scheme linked to the general objectives of the first and second national five-year development plans. The second request was for assistance in bringing about improvements in specific sectors of forestry, logging and industry, combined with a phased training program for technicians and research workers abroad.

The following is a brief summary of some of the stages followed in drawing up a guide to future development in forestry, forest industries and in general land-use planning in the country.

Background

The investigations began with an assessment of the requirements of forest products in relation to the expected economic development of the country and the prospective increase in population.

The data finally arrived at were:

	Approx., in mill. ha.	Percent of total
Present land area:	*149*	*100*
of which		
Forest area	90	60
Area under permanent agriculture	13	9
Nonclassified	45	31
(Area under shifting cultivation)	(12)	
Present population:		85 million
Estimated population by 1957:		115 million

Estimated present annual requirements of forest products:

	mill. m³
Timber	5
Fuelwood	65
Total	70

This total is equivalent to about 0.8 cubic meter *per caput* per year, but does not include bamboo which is the main rural building material in Java, Bali and some parts of Sulawesi (Celebes). By including bamboo and other organic building materials, a total consumption of about 1 cubic meter *per caput per annum* (in round-wood equivalent) is reached.

Fuel is by far the larger item of wood consumption (about 90 percent in the form of firewood and 10 percent as charcoal). The present pattern of energy consumption is approximately as follows:

	Percent
Woodfuel (including charcoal and agricultural waste)	80
Oil	15
Coal	3
Hydroelectric power	2

Oil (kerosene) consumption is fast increasing owing to the introduction of efficient kerosene burners in many households.

The largest amount of industrial timber (about 90 percent) is consumed for building and construction, especially for housing, and the next largest for packing material, about 7 percent, whereas timber for miscellaneous items such as furniture, matches, etc., represents about 3 percent.

The distribution of the forest resources varies between the island groups but the percentage of land area under forests is as follows:

	Percent
Java	22
Sumatra	60
Kalimantan	77
Sulawesi	53
Lesser Sunda Islands	20

The composition by forest types is estimated in round figures, to be:

	Percent
Primary rain forests	65
Secondary forests	15
Inland swamp forests	14
Teak plantations	1
Non-teak plantations	1
Mangrove forests	1
Other forests	3

It appeared from the investigations carried out that the recorded production of Indonesia is confined to about 50 percent of the timber and 3 percent of the

[1] Mr. von Monroy served in Indonesia under the United Nations Technical Assistance Administration.

FIGURE 1. – *A 38-year-old plantation of* Eucalyptus saligna, *Java (altitude 1,400 meters; height of trees up to 50 meters).*

fuelwood consumed. The balance of consumption comes from unrecorded cutting (gardens, farms, community forests not yet under government control, etc.). Java, with nearly 70 percent of the total Indonesian population, requires the bulk of all the forest output, but its forest area represents only 3 percent of the total forests of all the islands.

Development Proposals

In conducting his investigations and drawing up his proposals, the writer was given every assistance by the Directorate for Forestry and Land Utilization and by all other departments. He came to the conclusion that by 1975 requirements for forest products would have increased on an average by 50 percent as a result of the population growth and improved living standards. At the same time, the pattern of requirements would have considerably changed, and his proposed development program was adapted accordingly.

Afforestation program

The recorded annual output of the Indonesian forests amounts at present to only about 4 million cubic meters (timber and firewood), that is, about 0.05 cubic meter per year per hectare. The production potential, however, under the prevailing humid tropical conditions and with proper forest management can be put at 2.5 cubic meters for teak, 15 to 20 cubic meters for conifers, 20 to 25 cubic meters for certain soft broadleaved species (*Albizzia*, etc.) and even more for selected *Eucalyptus* species. This means that the ecological conditions of Indonesia present a production potential for certain fast-growing species (including bamboo) of up to 10 tons air-dry organic material per year per hectare, that is, about four times the average growth under the ecological conditions of Central Europe.

This is the reason for proposing a ten-year afforestation program, primarily for Java, to convert secondary forests and uncultivated lands into fast-growing plantations located as near as possible to the main centers of consumption. The annual target amounts to about 30,000 hectares of new plantations, mainly intended to supply cheap building materials, pulpwood, and wood for packaging, plywood and matches.

The implementation of this program has been in progress during the last three years and the results are favorable. The main species planted are: *Pinus merkusii*, *Agathis lorantifolia*, *Albizzia falcata*, *Anthocephalus cadamba*, and bamboo. Trials are also being made with various eucalypts and other exotic species.

Prewar in Java, forestry traditionally concentrated on intensive management of teak. The teak plantations on which the reputation of Indonesian forestry was founded still provide the bulk of the forest revenue and contribute, on less than 1 percent of the total forest area, about 80 percent of the gross forest income. Further increase of teak plantations, except for inferior grades is, however, not feasible for ecological reasons.

The possibility of embarking on a broad development program for the natural forests on the Outer Islands where *Dipterocarpus* and *Shorea* species prevail, has been widely discussed both from the technical and economic aspects. At present only 10 percent of Java's total wood requirements are supplied from the Outer Islands (mainly from Kalimantan). A further increase is technically possible but is, for the time being, scarcely an economic proposition because the efficient development of these areas requires large capital investment and a high standard of organization. Owing to the great distances involved in transport, timber from the Outer Islands must be more expensive than that produced on Java in fast-growing plantations near to the consumption centers and where wages are relatively much lower.

Moreover, the industrialization program needs a variety of raw materials, such as long-fibred pulpwood; bamboo for paper; soft broadleaved species for packaging and cheap housing, tough and light-colored species for matches, etc., whereas the natural forests of the Outer Islands supply mainly heavier species more suitable for general construction and similar purposes.

These are some of the reasons why the afforestation program has been started on Java where two thirds of the total population are concentrated and where tree cover also serves an important function in erosion control.

If the planting program is continued for ten years according to the schedules now laid down, the production capacity of the country as a whole will be doubled — without reducing the agricultural area — and at the same time the timber crops will be sufficiently varied to supply the main raw material requirements.

A similar program is under consideration for the wastelands covered by alang-alang (*Imperata cylindrica*) on the Outer Islands. These areas add up to more than 10 million hectares and are in part well suited to the production of long-fibred pulpwood for use by local mills and also, along the coast, for export in semi-finished form.

Industrial program

Housing [2]

The following figures show the present housing situation:

Region	Brick houses	Timber houses	Mixed timber/ bamboo houses	Bamboo dwellings
	..... *percent*			
Java	5	small	50	45
Outer Islands	2	90	8	small
Total, Indonesia	3	28	31	32

While bamboo is the principal housing material used in Java, on the Outer Islands timber is more common. The trend even in Java is towards more permanent dwellings and this means timber of good durability, large-sized building boards, insulating roof material, etc. This requires a supply of more and reasonably priced

[2] *See also* Housing Development In Indonesia, *Unasylva*, Volume 10, Number 1, 1956.

Figure 2. – *A dense clump of the bamboos commonly used for housing in Java.*

lumber (suitably treated or protected), production of mineralized wood wool slabs or hollow blocks, and of various types of building boards, partly with surface treatment or other types of water-resistant preservation. Factories to provide such materials were included in the first and second five-year plans.

Soap, etc.

The soap-, margarine- and cigarette-industries require annually about 300,000 cubic meters roundwood timber for conversion to packing cases. The most suitable species is *Albizzia falcata* (density about 0.3).

Only 50 percent of plywood chests for tea export are presently produced within the country in spite of the availability of raw material. Under the first and second five-year plans, two additional plywood factories will be erected to make the country self-sufficient in this commodity. A total of about 50,000 cubic meters of roundwood will be required to supply these mills and furnish the packing material for a tea export of nearly 50,000 tons (i.e., a ratio of 1 cubic meter of roundwood for 1 ton of tea).

Pulp and paper

Import restrictions keep down the present paper consumption in Indonesia to about 100,000 tons per year, i.e., 1.2 kilograms *per caput*. The actual requirements are considerably higher.

The domestic paper production, based on rice straw, is negligible and does not exceed 5,000 tons per year. But, within a ten-year period, Indonesia can become self-sufficient in the principal commercial types of paper. The main fibre raw material will be *Pinus merkusii*, *Agathis loranthifolia*, bamboo and certain hardwoods for admixture, as well as bagasse and rice straw.

This new industry — five factories are programed — will be based mainly on the fast-growing forest plantations on Java and Sumatra. Celebes could supply raw material from natural bamboo forests for an additional plant.

Under Indonesian conditions, a net plantation area of 5,000 hectares is considered sufficient to provide raw material for a plant with a capacity of 12,000 tons of paper per year.

Matches

During the last three years Indonesia has become basically self-sufficient in matches. The raw material for this industry is also mainly supplied from forest plantations (*Anthocephalus cadamba* and *Pinus merkusii*).

The present consumption (about 500 sticks *per caput per annum*) is likely to increase very considerably during the next decade.

These few examples show that in the industrial field progress is being made in spite of many difficulties.

Program of research and development

In new countries which are making every effort to build up a sound economy in the shortest possible time, technical assistance, both international and bilateral, can contribute considerably to efficient planning and practical implementation.

Figure 3. – *A plantation of* Pinus merkusii *in Northern Sumatra.*

FIGURE 4. – *Teak logs cut from a plantation, awaiting shipment.*

The Indonesian government requested international co-operation mainly along the following lines:

1. Assistance in the preparation of a forest industries development program, based on a thorough analysis of the present and future requirements, an appraisal of the existing and potential resources and a detailed plan for integrating forestry and forest industries into a dynamic national economy.
2. Co-operation in specific fields of forestry, such as logging, forest inventory, and yield studies.
3. Survey of specific industries (matches, plywood, building material, paper) combined with demonstration of improved processing methods.
4. Industrial runs with Indonesian raw materials to find out how to adjust the processing methods to these raw materials and markets.
5. Training of staff in the field and abroad, preferably by persons familiar with the country.
6. Assistance in the preparation of an *Atlas of Indonesian Resources and Land Use*, indispensable for integrated planning.

Bilateral technical assistance arrangements have been made to start investigations on " minor " forest products which are so important in Indonesia, primarily rattan of which Indonesia's share in the world market exceeds 90 percent.

Another field of bilateral technical assistance concerns the improvement of cooking devices. Studies in Switzerland, initiated by FAO, have proved that, by slight modifications, a 40 to 50 percent saving of the fuel from forest sources can be made.

By agreement with some European countries, a new system of bilateral technical assistance under FAO guidance has been developed to adjust processing methods to the technical and economic requirements of Indonesia. The basic point is that most of the modern techniques which originated in the temperate zone are not suited for direct application to the raw materials, climate and economic conditions of the less-developed areas of the world.

A two-year research and development program, in co-operation with specialized Central European institutes and industries, has therefore been started. Indonesia will provide the raw materials for laboratory tests and industrial runs and will also designate staff to work on the spot.

Results obtained up to now in specific fields (preservation of timber, bamboo and rattan, development of new types of derived building materials suitable for the humid tropics, stabilization of Indonesian timbers for pencil production and similar purposes, binders from indigenous sources, high-yield pulping methods for tropical raw materials, etc.) prove how much time and money can be saved by such co-ordinated efforts.

These examples show that, for new countries embarking on a dynamic development program, the usual system of technical assistance, mainly confined to assignment of experts and granting of fellowships, should be supplemented by long-term co-operation for improvement of basic techniques in the various fields of forestry and forest products, adjusted to the technical requirements and to the economy of the country concerned. In this respect, Indonesia, in co-operation with the United Nations Technical Assistance Administration (UNTAA) and FAO, has made a considerable step forward.

The Work of FAO

European Forestry Commission

Turkey acted as host to the eighth session of the permanent Working Party on Afforestation and Reforestation of FAO's European Forestry Commission, held from 21 to 25 April 1959 under the chairmanship of Sir Henry Beresford-Peirse (United Kingdom) and with J. de Vaissière (France) serving as Rapporteur.

The working party reviewed the afforestation and reforestation operations reported as having been carried out by the member countries of the region during 1958. Extensions of existing forests amounted to 281,000 hectares, and 241,000 hectares of degraded forest had been subject to improvement treatment, which was a satisfactory balance. The area of new plantations established outside reserved forests proper reached 38,000 hectares.

Present costs of planting operations came in for a considerable amount of discussion, and it was decided to make further detailed investigations. The costs of soil preparation are to be distinguished from expenditure on actual planting work.

The labor situation for forestry work was reviewed on the basis of a preliminary enquiry carried out by the Secretariat. Reliable figures were lacking on workers employed and on their terms of employment, and it was proposed that a more detailed survey be made in co-operation with the International Labour Organisation.

Before this session in Turkey, members of the EFC Working Party on Torrent Control had been invited by the Greek Government to make a short study tour in the region of Salonika and the Strymon valley to see watershed management work. This tour was held from 19 to 21 April and the participants then went on to Istanbul, where they joined the members of the other working party. All then took part in a meeting and study tour organized jointly with the Subcommission on Land and Water Use of FAO's European Commission on Agriculture (ECA).

This was a first attempt at the international level to hold field discussions between agriculturists and foresters on problems of land-use, and it met with commendable degree of success. The tour was well prepared by the Agriculture or Forest Administration of the Turkish Government and led the participants first to catchment areas in the immediate vicinity of Istanbul, where were posed special problems attaching to the extension of large urban areas, then to Izmit, Bursa and Izmir.

On-the-spot discussions were followed by meetings of small discussion groups, and finally by a plenary meeting presided over by Mr. G. R. Ytterborn, Chairman of the ECA Subcommission, and with the Chairman of EFC Working Party on Afforestation and Reforestation acting as Rapporteur. The results of these discussions have been conveyed to the two parent bodies.

The exchange of views that took place was of considerable interest, and suggests that permanent machinery should be established both at the national and international level, for consultation and co-ordination between agriculturists, foresters and engineers concerned with problems of land-use and soil and water conservation. There are many subjects of common interest which demand common consideration. Although limited to the European region, this experiment may reveal a pattern for better co-ordination between foresters and agriculturists in other parts of the world also.

Technical Assistance Reports

Over 1,000 reports of technical assistance missions have now been issued by FAO. These reports incorporate the conclusions and recommendations made by technical assistance officers on completion of their field assignments in individual countries.

A fifth of the reports issued to date deal with forestry in its widest sense, and they relate to missions carried out in 50 countries: 23 percent concern countries in the Asia and Far East region, 18 percent, Europe, 36 percent; Latin America; 14 percent, the Near East; and 3 percent, Africa.

It is to be recalled that the FAO Expanded Technical Assistance Program first got under way with the signing of agreements for advice on forestry development in Guatemala and Burma in September 1950. The first formal technical assistance report on forestry to be submitted to a Government by FAO was *An Austrian Investment Program for Forestry and Forest Industries*, drawn up by Egon Glesinger (now Director of FAO's Forestry and Forest Products Division) and D. R. Cameron, then head of FAO's European forestry office. This was presented to the Austrian Government in 1950. The most recent to be issued (ETAP Report No. 1087) deals with a logging training center in India.

The greatest number of forestry reports, nearly one quarter, have dealt with the planning of forest and forest industries development in 31 different countries, ranging from the geographical extremes of the Amazon basin of Brazil to Afghanistan. Pulp and paper development surveys were carried out in 1952/53 in 17 countries throughout the world, as well as in the Caribbean area and Central America. In the past twelve months, surveys have been made on the possible developments in the teakwood trade of Burma, the forest industry prospects of Ghana, and the timber potential of Liberia.

Forest surveys and mapping have been executed by FAO technical assistance officers on areas where little if any such work had been done hitherto, for instance, selected forest areas of the Amazon basin and the northern teak-bearing forests of Thailand. The use of aerial photography for forest inventory work has been the subject of 11 reports to seven countries.

It the field of forest and forest products research, 22 missions have been carried out in 12 countries. Assignments in silviculture and planting have been made in 18 countries, ranging from Paraguay to Malta. Soil conservation, watershed management and forest range management are the subjects of other reports. Sixteen reports are concerned specifically with timber extraction, from the logging of pulpwood in Indonesia to mountain logging in Mexico. The development of sawmills, plywood mills and other primary industries accounts for many more reports.

FAO has sponsored or participated in the organization of many regional projects, training centers, and symposia held in various parts of the world. Reports have been issued, for instance, covering a forest fire control study tour held in the United States of America, a study tour on eucalypts organized in Australia, another on the silviculture of plantations held in Czechoslovakia, and a study tour on arid-zone forestry that took place in the U.S.S.R. in 1956.

Each technical assistance report is, of course, in the first instance a confidential report made to government authorities. Usually, however, the Government concerned agrees to the general release of the document after a certain period, and a limited number of copies can generally be supplied on request. Reports, as they appear, are noted in *Forestry Abstracts,* published by the Commonwealth Forestry Bureau, Oxford, England.

A Forestry Program for Africa

Africa, it is commonly said, is a continent in ferment. The Ninth Session of the FAO Conference, 1957, devoted a considerable amount of time to debating what should be FAO's role and policy in the region. It decided to establish in Africa, as had earlier been done for other regions, a regional office through which co-ordination could be strengthened between governments in the fields of activity covered by the Organization. Since then, the Director-General has appointed Mr. P. Terver, a former member of the Forestry and Forest Products Division, as his Regional Representative. Forestry officers will join the regional office which is to be established initially at Accra, Ghana, toward the close of this year. A small group is also to work with the new United Nations Economic Commission for Africa at Addis Ababa, and the next session of the FAO Conference, meeting in November 1959, will consider creating two other subregional offices.

When the tasks already accomplished and the work that lies ahead of the forest services of the various countries of Africa are compared it is seen that, while much has been done, yet much still remains to be achieved in the field of forestry. Budget restrictions and the emphasis given to industrial and agricultural development threaten to decrease the resources made available to forest services which might result in a reduction of already insufficient cadres. Governments need to be constantly reminded that the forest is a source of direct or indirect wealth, and has a very definite role to play in land use, soil conservation and the regulation of stream flow; and that these values are constantly and often increasingly menaced from all sides. Agriculture, livestock breeding and industrial plantations are clamoring for new land. And from within, the selective character of timber exploitation which concentrates only on species of the highest commercial value, may bring about the irrevocable impoverishment of extensive areas.

Surveys of the natural forest resources and the study of their behavior by observation and through the development of research, which is particularly the concern of the Commission for Technical Co-operation in Africa South of the Sahara (CCTA), are still only partially-explored realms of activity, and their results must be correlated to other studies on trends in wood requirements. The lack of such surveys has often given rise to an idea of the inexhaustibility of the forest resources of certain areas of the region, which has sometimes placed the forest services in an even more difficult situation when asking for the funds to carry out their work.

Land-use planning is an immediate necessity in the face of increasing demographic pressure and economic expansion. During the course of the struggle for authority which often accompanies periods of national evolution, there is a constant risk of the removal of the few deterrents that it has been possible to raise in the course of years in opposition to the irrational destruction of forest land. There is, therefore, urgent need here for the sort of action for which FAO was created and which it bears direct responsibility for developing.

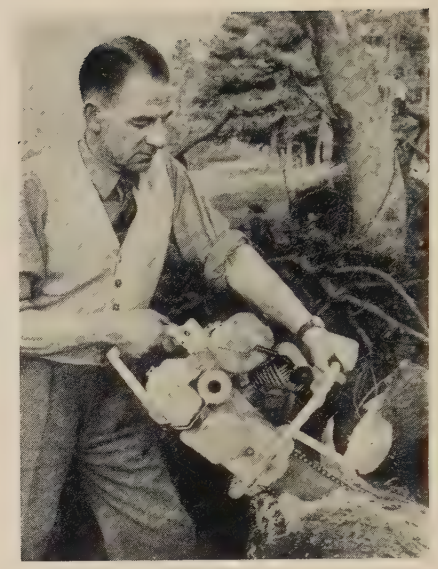
To keep matters before the attention of national authorities in other regions, FAO has established intergovernment Regional Forestry Commissions. These meet at periodic intervals to review the progress of national forest policies. Views on development programs are exchanged and the obstacles encountered are examined in the light of experience acquired in other countries. This exchange of ideas and the opportunities created for personal contacts have considerable value in themselves. But what is more important is that recommendations can be made to the governments of the region for the adoption of measures calculated to assist in the development of the forest economy. These recommendations, coming from an international body created by the governments themselves, generally carry more weight than if presented by the individual forest services. It is possible that member countries in Africa will ask the Organization in due course to set up a similar regional forestry commission to promote forest development in that region.

Equipment Section

Atlas Copco "Cobra" Motor Drill and Breaker. — Combined lightweight 53 lb. (24 kg.) multi-purpose motor drill and breaker. Totally enclosed pull-type starter. Rapid steel changes. Air-blown flushing eliminates exhaust gases. Floatless carburetor permits drilling in all positions from vertical to 45°; 3 min. conversion from rock drill to breaker.

Specifications: Overall length 24 in. (61 cm.); drilling speed in hard granite using 1 1/8 in. (2.9 cm.) tungsten carbide tipped bits, net rate 8 in. (20 cm.) min. overall rate 26 ft. (8 m.) h.; approx. max. depth of hole 13 ft. (4 m.); rpm 2,300; tank capacity 1/3 Imp. gal. (1.5 l.), fuel/oil mixture 16:1; approx. drill meterage/fuel unit, 75-100 ft. (23-30 m.) per Imp. gal. (4.5 l.).

Atlas Copco, Viale Marche 15, Milano, Italy.



Danarm DD.8F Mark II Saw. — Direct drive. Weight 28 lb. (12.7 kg.) complete. Cutting speed 15 sq.in/sec. (97 cm²/sec.) in dry elm. Can be equipped with cutter bars from 18 to 28 in. (46 to 71 cm.) cutting width. Available in two-man gear reduction saw which is suitable for cutting widths of up to 4 ft. (1.22 m.). Engine 100 cc. (6.1 cu.in.) capacity — 5 bhp. Magneto totally enclosed. Cylinder and head air-cooled by a ducted centrifugal fan. Automatic rewind starter removable to expose a traditional rope pulley. Diaphragm pump integral with carburetor. Saws in all positions.

Automatic petroil lubrification of engine.

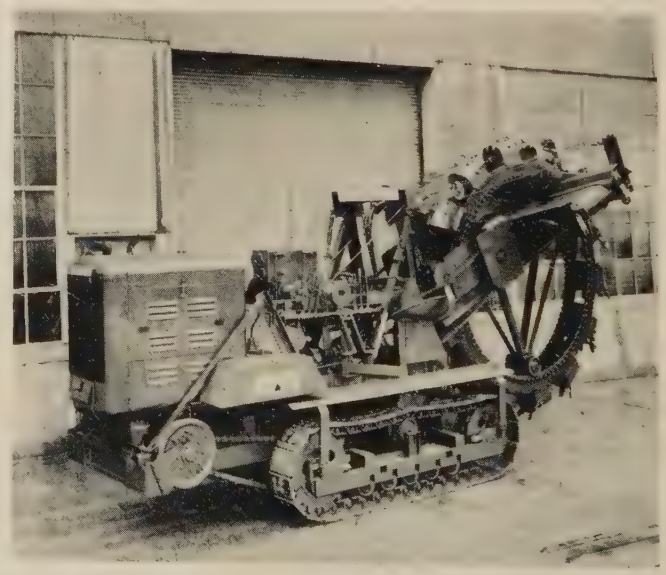
J. Clubley Armstrong Danarm Ltd. Abford House, Wilton Road, London S.W.1, England.

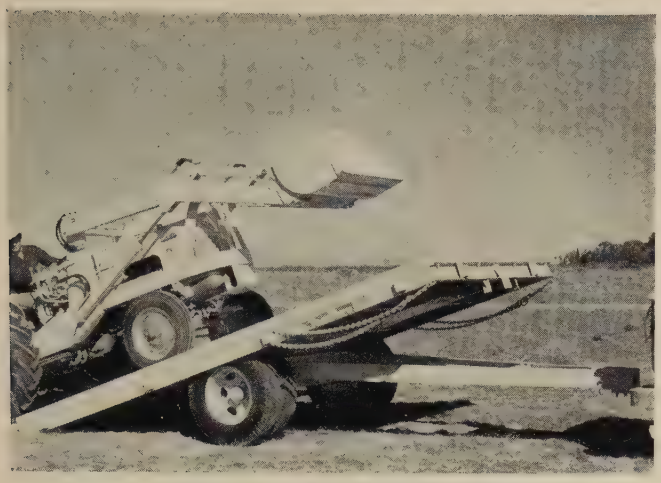
Morton Portable Gulleting Machine. — Operated from any power unit, working control with adjustable balance arm. Swivel motion on grinder head enables tooth contour to be followed. Depth of cut adjustable by two bolts. The cone fitting for saw blade fits any size hole. Adjustable for grinding plow disks.

C.M.H. Morton Limited, 459 Magill Road, St. Morris, S. Australia.

Cleveland Trencher Model J-20. — Smallest of four new Cleveland trencher models, features new type V-shaped conveyor, driven, shifted and reversed in direction of discharge by independent hydraulic drive within conveyor, all lever-controlled from operator's seat. Friction-free, non-packing crawler tracks are military-type, dually supported and driven on both ends of crawler pins.

Cleveland Trencher Company, 20100 St. Clair Avenue, Cleveland 17, Ohio, U.S.A.



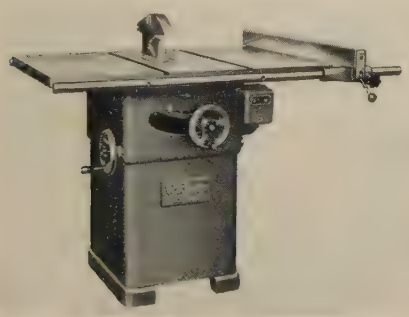


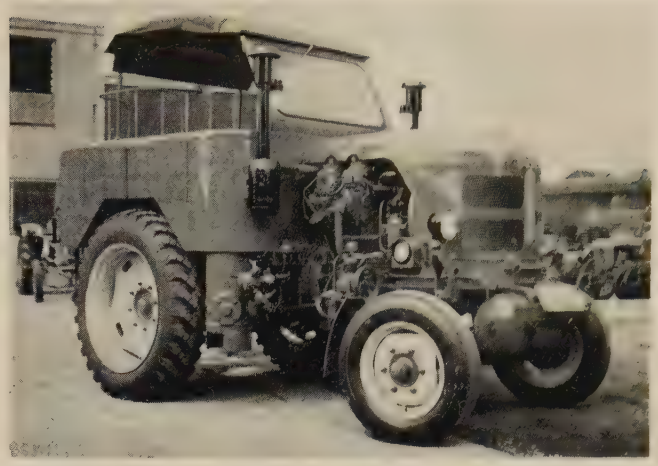
Model 90 Trailer. — *Specifications*: Rated capacity (gross) 5 tons. Weight of trailer 2,650 lb. (1,202 kg.). Platform width 8 ft. (2.44 m.). Platform length 14 ft. (4.27 m.). Tires: four 7.50 × 16,8 ply. Frame: welded channel. Hitch: pintle with safety chains.

J. I. Case Company, Racine, Wisconsin, U.S.A.

Saw Bench. — 10 in. (25.4 cm.) tilting arbor saw bench model A.G.S. Max. depth of cut 3 1/8 in. (8 cm.); cut to center of panel 50 in. (1.27 m.) wide. Table almost 8 sq.ft. (0.74 m^2) supports large plywood or plastic sheets. Special extension with adjustable platform and floor supports can be fitted on either side of machine, increasing capacity to 48 in. (1.22 m.) from saw to guide plate. Saw cants to 45° by handwheel in front of machine, rises and falls by screw movement. On both saw movements rigid locks provided. Saw guard and riving knife automatically cant with saw but can be rapidly removed and replaced before and after moulding operations. Miter gauge for cross cutting, mitering and compound angle sawing.

Wadkin Ltd., Green Lane Works, Leicester, England.



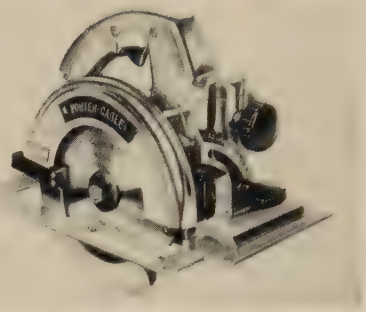


O and K Compressor Tractor. — Diesel drive can simply be switched over, i.e. without conversions, to the following uses: diesel tractor, diesel compressor, diesel welding and cutting set, diesel generator set, diesel rope winch.

Specifications: Engine output (tractor operation) is 40 h.p. at 1,500 rpm, compressor 32 h.p. at 1,500 rpm; 4 cylinders 5 speeds from 2.3 mph (3.7 km./h.) to 13.7 mph (22.0 km./h.); reverse 3.1 mph (5 km./h.). Power take-off speed 540 rpm.

Dimensions: length 11 ft. 2 in. (3,400 mm.); width 5 ft. 5 in. (1,600 mm.); clearance 11 3/4 in. (300 mm.); net weight 5,864 lb. (2,660 kg.). *Compressor*: air delivery 113 cu. ft. (3.2 m^3) per min. at 1,500 rpm, air pressure 85 lb./sq.in. (6 atü).

Orenstein-Koppel und Lübecker Maschinenbau Aktiengesellschaft, Dortmund, Balkenstrasse 14-20, Germany.

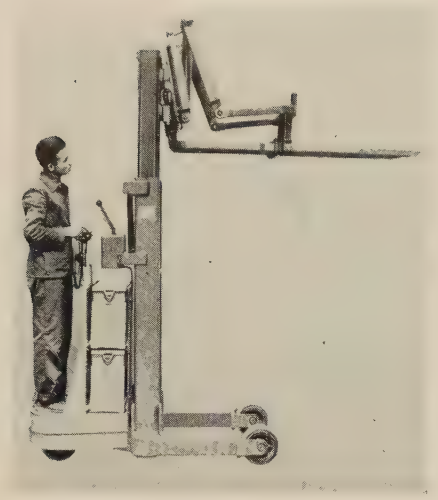


Model 146A Heavy Duty Saw. — 6 1/2 in. (16.5 cm.) saw for building and industrial trades. Telescoping spring guard avoids jamming, eliminates drag while cutting. Kickproof clutch stops saw blade instantly, eliminates dangerous bucking, prevents motor and switch burn-outs. Handle grip with trigger switch over center of gravity assures safer one-hand control of saw. *Specifications*: Model 146A has polished aluminum frame, 10-amp. universal motor turns free blade at 6,000 rpm and drives it under load at 4,000 rpm. Maximum depth of cut at 90°, 2 1/4 in. (5.7 cm.) at 45°, 1 3/4 in. (4.4 cm.) for 2 in. (5 cm.) dressed lumber.

Porter-Cable Machine Company, Syracuse, New York, U.S.A.

Heavy Duty Atlas Crane *Specifications*: Tubes in telescope: 1st tube 5 in. (12.7 cm.) O.D. 5/16 in. (8 mm.) wall. 2nd tube 6 1/4 in. (16 cm.) O.D. 1/4 in. (6.4 mm.) wall. 3rd tube 7 1/2 in. (19 cm.) O.D. 1/4 in. (6.4 mm.) wall. 4th tube 8 5/8 in. (22 cm.) O.D. 5/16 in. (8 mm.) wall. 4 3/4 h.p. totally enclosed fan-cooled motors. 2,500 watt Kohler generator of 115 volts. Crane rises from horizontal to 80° in 3 min., extends from 30 ft. (9.14 m.) to 80 ft. (24.40 m.) in 3 min., rotates 360° in 2 min.

Atlas Crane Co., 325 Miller Pl., Mount Vernon, N. Y., U.S.A.

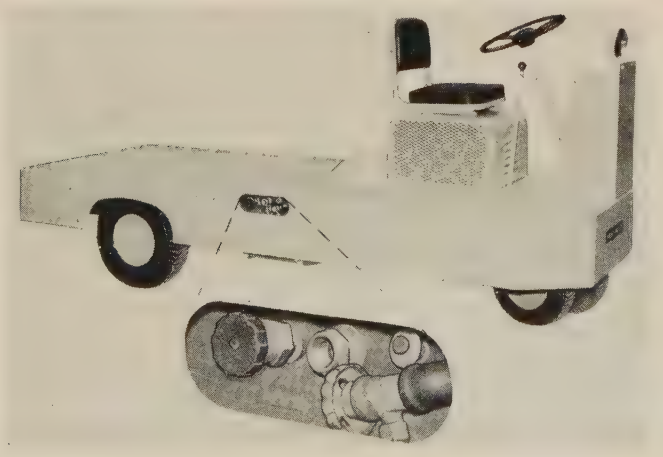


Fork Lift Truck With Forks Extended. — *Technical data*: load capacity 2,200 lb. (998 kg.); lifting height up to 18 ft. (5.5 m.); fork length 35 ½ in. (90 cm.); overall width of forks 22 in. (56 cm.); turning radius 59 in. (150 cm.). Travel speed loaded 4 mph (6.4 km./h.) unloaded 4.6 mph (7.4 km./h.). Wheel base 49 5/8 in. (126 cm.). Travel motor 2.4 h.p. Lift motor 2.4 or 5 h.p. Net weight 3,395 lb. (1,540 kg.).

G. Hunter (London) Ltd., 80 Fenchurch Street, London E.C.1, England.

Platform Truck Model F-40 — 4,000 lb. (1,815 kg.) capacity, hydraulic torque converter drive provides space to handle long bar stock. *Specifications*: width 42 in. (1.07 m.); length 122 in. (3.10 m.). Weight 1,940 lb. (880 kg.). Speed 12 mph (19.3 km./h.). Tractive effort 1,200 lb. (545 kg.) max.

Prime-Mover Co., Muscatine, Iowa, U.S.A.

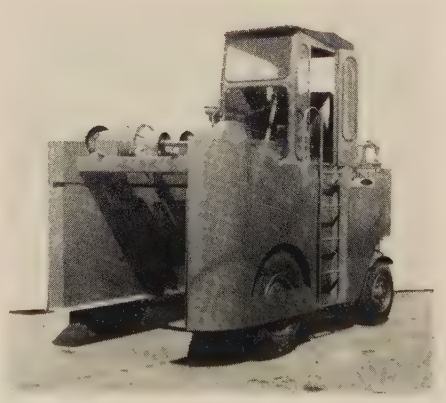


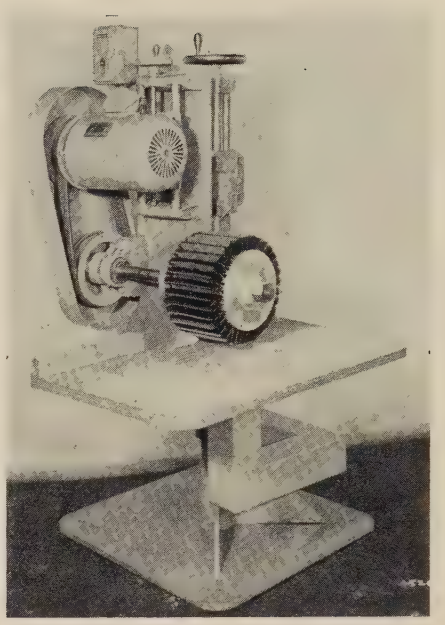
Universally Adjustable Spindle Stand. — Motor can be turned to point spindle straight up, straight down and through all 180° between. 20 in. (50 cm.) vertical adjustment, 5 in. (12.7 cm.) adjustment lengthwise of spindle. Thus head can be brought into proper relation with any surface of any pattern. On narrow patterns or edgework full 4 in. (10 cm.) width of abrasive can be used by resetting head with 5 in. (12.7 cm.) longitudinal adjustment.

Grinding and Polishing Machinery Corporation, 2530 Winthrop Avenue, Indianapolis 5, U.S.A.

Gerlinger Carrier Model 12RH-12,000 lb. Capacity Hydraulic Lift. — *Specifications*: Engine Ford 130 h.p. 6 cylinder industrial engine. Operator's position allows a 360° visibility. Dimensions according to the model: load width from 40-52 in. (102-132 cm.), load height from 42-52 in. (107-132 cm.), overall width 75 3/4-87 3/4 in. (192-223 cm.), overall length 146 in. (371 cm.), turning radius 5 ft. 10 in. (1.78 m.).

Gerlinger Carrier Co., Dallas, Oregon, U.S.A.





Lumber Pallet Jack. — Ratchet lever jack designed to speed unloading of lumber pallets from railroad cars at lumber or freight yards. Useful for yards not equipped with complete mechanical unloading equipment. Low-cost substitute for additional fork truck or other handling equipment used for unloading at all yards. Has toe lift to which 40 in. (1 m.) steel angle is welded. Angle inserted under one end of lumber pallet. Load raised until two pipes or cylinders can be placed beneath. Pallet then rolled to car door for transfer either to truck bed or fork truck and eventual placement in yard. This model is standard single-acting, automatic-lowering jack, 28 in. (71 cm.) high, with 19 in. (48 cm.) rise, 15 ton capacity, weight 98 lb. (45 kg.).

Joyce Cridland Co., 2027 East First Street, Dayton 2, Ohio, U.S.A.

News of the World

Argentina

• *Repoblación Forestal con Pinos y Eucalyptus en Misiones* describes the results obtained by the Cellulosa Argentine Company in planting the native *Araucaria angustifolia* and introduced *Eucalyptus* and *Pinus* species for pulpwood in the north-eastern section of Argentina.

Misiones is a subtropical territory at latitude 24°-28° S; rains average 1,600-2,000 mm. (63-79 in.), predominant in winter; average temperature 20°C. (69°F.), with average for summer of 25°C. (73.5°F.) and winter of 15°C. (59.5°F.). The elevation ranges from 400 m. (1,300 ft.) to 1,000 m. (3,280 ft.) approximately. Eighty percent of the territory is covered by natural broadleaved forest associated with *Araucaria* in the northern corner as an extension of its Brazilian range. The main species planted by the Company are *Araucaria angustifolia, Pinus elliottii, P. taeda, P. caribaea, P. hondurensis, P. oocarpa, P. patula, Cunninghamia lanceolata, Eucalyptus saligna* and *E. grandis.*

The paper describes planting techniques, treatments and growth of these species. *Araucaria,* mostly direct seeded, produces from 16 to 25 m³ per hectare per year (230-360 cubic feet per acre per year) on a 20- to 25- year rotation. With thinnings at 8 years and every fourth year thereafter, a seven-year plantation of *Eucalyptus saligna* clearcut is estimated to give 170 to 210 metric tons per hectare (70 to 85 metric tons per acre); a final cut can be expected 16 to 17 years after the original plantation.

Thinnings of *Araucaria* plantations pay in 10 years all capitalized costs; for *Eucalyptus saligna,* total costs (from planting to factory pulpwood yard) are 65 percent of selling price.

The report aims at encouraging farmers to plant trees not only for pulpwood, but for other uses, such as resin. It is printed on paper containing 25 percent of pulp of *Araucaria angustifolia* and 35 percent of *Eucalyptus,* both from plantations in Misiones.

Australia

• Planting programs developed over the past 30 years have had no great concern about the wood quality of the crop. In planning for the future the opportunity exists for the growing of wood with predetermined properties, as a result of recent developments in tree-breeding research. This is the theme of an article "Desirable Trees for Paper" by two members of the Commonwealth Scientific and Industrial Research Organization, in a recent issue of *Pulp and Paper International.* The editor of this magazine, Mr. Wilson, on a recent visit to FAO Headquarters, drew attention to this article since FAO aims to give increasing emphasis to the whole field of forest tree breeding work.

The authors give the desired qualities of trees for paper as:

Softwoods

1. higher than average fibre length for the species;
2. in plantation-grown exotics late wood forming more than 15 percent of the growth ring, but not more than 50 percent;
3. higher than average cellulose content for the species;
4. low extractive content;
5. provided 1, 2 and 3 are satisfactory, a growth rate as rapid as the economics of plantation management will allow.

Hardwoods

1. higher than average fibre length for the species;
2. cell wall thickness such that $2w/l<1$;
3. basic density lower than average for the species (this to be correlated with cell wall thickness);
4. high ratio of fibres to vessels, rays, and parenchyma (also associated with density);
5. low extractive content;
6. higher than average cellulose content for the species;
7. suitable hemicellulose content.

The extent to which these features can be controlled genetically is still being investigated. One of the great problems is how to obtain answers in a reasonable period of time. Geneticists working with annuals have a definite chance of obtaining results quickly. With trees it is much harder and, if one had to wait until they reached maturity, progress in this line of research would be slow. However, it has been found possible to get ideas of wood quality by the examination of wood from young stems. From the data obtained a suggested order of priority can be provided on the basis of wood properties. Trees chosen as desired parents will provide material for vegetative propagation or grafting, and so progeny can be developed quickly for planting out in a seed orchard.

Brazil

• The most modern capital city of any nation in the world, built on revolutionary architectural lines, is developing in the heart of Brazil. The location was first selected around 50 years ago, the result of reasoning. Until three years ago nothing very concrete was done about it. Now the construction of Brasilia is so far advanced that there is no doubt that it will really be Brazil's new capital. With it, it is claimed, a new era in forestry in Brazil has started.

Experiments are under way to find the most successful types of trees for city avenues and parks. Many thousands of trees are ready for transplantation, mostly flamboyants, eucalyptus and various species of pines. A forest belt will be established over the catchment area of the 40 square mile (103 square kilometers) artificial lake that will almost surround the new capital: no factory, industry or any air- or water-pollution will be permitted. On the central plateau on which Brasilia is located a great afforestation program is planned in six districts. Within 30 years the entire softwood needs of the capital will be served.

In January 1959 the head of the FAO forestry mission in the Amazon region attended a ceremony when the President of Brazil supervised the felling of the last tree on the new road alignment for a federal highway between Brasilia and Belem at the mouth of the Amazon basin. The ceremony took place some 350 kilometers south of Belem. The whole road will be 2,276 kilometers in length and eventually will continue a similar distance to Porto Alegre in the far south of Brazil. Brasilia will be the point where the two roads, one from the pampas and the other from the virgin forest, meet in

CANADA: *An impressive feature of an Electric Power Development project in Quebec is the largest woodstave pipeline in the world. Built of Douglas fir, pressure-creosoted, it is supported by steel cradles placed on concrete sills. Some 1,000 tons of steel strapping are used to bind the wood. The pipe is 5,609 feet (1,709 meters) long, has an inside diameter of 18 feet (5.49 meters) and will pass a normal flow of 2,500 cubic feet of water (71 cubic meters) per second and a maximum of 3,200 cubic feet (90 cubic meters).*

Courtesy, Edmund T. Nesbitt

the hinterland. The northern road is expected to give a tremendous impulse to the development of the Amazon region.

Burma

• With the arrival of more equipment, expansion of mechanical extraction is under way to make good the deficiency in haulage power due to depleted elephant herds. The degree of mechanization recommended by FAO missions has proved its feasibility and merits, and has been justified by greater outturn and considerable reduction of the time which teak logs take in transit from stump to mills.

Along with mechanized extraction, another almost revolutionary step has been taken with the green felling of teak in middle Burma. The conventional practice is to kill the teak trees by girdling, after which they are left standing for three years to dry out and become floatable before being felled and logged. Milling of green teak is easier with less blunting effects on saws, while seasoning of the converted timber takes less time than drying out in the forest. This method of working is likely gradually to spread to all parts of Burma except in very rugged terrain with sparse stocking of teak.

Canada

• All the provincial forestry associations supported by the public have been welded into one national federation. Under the federation the provincial associations retain their autonomy, but they will direct the national association and speak with a united voice through it. The separate provincial forestry associations had grown up because of different needs; the French language in Quebec; the differing forests in British Columbia; the need for windbreaks and tree planting projects on the Prairies; and special regional needs elsewhere, including youth education.

The Canadian Forestry Association had recognized for some time that a regrouping of the provincial forestry associations was essential if funds contributed by the public were to be employed with increasing effectiveness to educate the public about the importance of the forests. Canada is a new country and has enormous natural resources but they are not inexhaustible. The association was launched in the spring of 1900 by a small group of devoted leaders in Ottawa who were concerned primarily with prevention of the tremendous forest fires which devastated the country at that time. But public opinion on the need for preserving, improving, and managing the forests was lacking, or at best, apathetic. As the association grew in stature, it gained in financial support from individuals, business men, industry, and from the provincial and federal government departments concerned with the forests.

The association now provides information on Canada's resources through every known medium, including press, radio, magazines, bulletins, posters, lecture tours, and public addresses. It uses television and other modern means of communication. The small cash budget of the association is enormously supplemented by the amounts of contributed time, services, and materials freely given by many organizations.

Federal Republic of Germany

• Genetics and forest tree breeding are again in the news with the publication of *Genetik und Züchtung der Waldbäume* [1] in Germany. Described as a hybrid between an introduction and a handbook, the book attempts to extract from the literature already published those elements that have an important bearing on research and application.

The basis of forest genetics is presented in terms of natural variation, propagation mechanism, heredity, chromosomes, and races. Techniques of tree breeding are discussed and brief descriptions given of the status of genetics work with various genera of conifers and broadleaved trees.

The book contains valuable reference lists, general and specific, and useful author and subject indexes.

Another useful book recently published in Germany is *Die Pappel: Anbau, Pflege, Verwertung*,[2] a practical guide to the care and management of poplars. It presents in condensed form the elements of establishing, maintaining, protecting, and utilizing poplars for local conditions in Germany.

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[1] ROHMEDER, E. and SCHÖNBACH E. *Genetik und Züchtung der Waldbäume*, 338 pp. illus., Hamburg, Paul Parey, 1959. 38 DM.

[2] *Die Pappel: Anbau, Pflege, Verwertung*, edited by Prof. Dr. H. Zycha with contributions by Dr. E. Röhrig, B. Rettlebach, Dr. W. Knigge. 121 pp. illus., Hamburg, Paul Parey, 1959. 14 DM.

Finland

• A major event in the forestry world was the celebration on 15 May 1959 of the 100th anniversary of the founding of the Finnish State Board of Forestry. Festivities were held in several localities to mark the centenary but the most important occasion was a meeting held in the grand hall of the University of Helsinki, honoured by the presence of the President of Finland, Dr. Urho Kekkonen. Among the numerous guests every feature of Finland's life as well as many foreign countries were represented.

The Director of the Finnish State Board of Forestry, Dr. Martti Lappi-Sappälä, described the stupendous changes which had occurred in Finnish forestry over the last 100 years: "A hundred years ago hardly anybody would have imagined that the forests of Finland would become the cornerstone of the nation's economy." The Director-General of the Board, Dr. N. A. Osara, reviewed these developments statistically. During the last century annual removals of over 300,000 cubic meters were reached only in occasional years. One million cubic meters of timber was cut from the state forests for the first time in 1907. In the 1920's annual removals went beyond 4 million cubic meters and in the 1950's beyond 5 million cubic meters. Present removals are approximately 20 times as much as the average for the 19th century. The progress indicated by these figures is still more striking when one considers that the area of state forests has decreased since the second world war. The average annual cutting target for the next 10 years is 6.7 million cubic meters.

The total income of the Forestry Board comes mostly from sales of timber: it was 12.5 billion Finmarks (U.S.$39 million) in 1958, and the profit to the state was 2.7 billion Finmarks (U.S.$8.4 million).

Dr. Osara and his colleagues of the Forestry Board received many warm congratulations. At the reception in their honour were the Prime Minister of Finland and many other notables. The Director of the Forestry and Forest Products Division, Egon Glesinger, represented FAO at the celebrations.

Japan

• The Research and Extension Service Section of the Forestry Agency has a program of extension activities directed towards improving techniques and operations throughout the sawmill industry. Research towards the same end is carried out through six prefectural forest experiment stations (wood technology divisions), technical schools and some universities: bulletins and notes are published on developments and recommended practices. Training courses are arranged in saw maintainance and in the lay-out and operation of equipment.

Since the country's sawmill industry comprises about 30,000 individual sawmills, it is understandable that the extension program is not easy. Specialists in the extension service have to give technical advice to every mill and also arrange seminars for owners and managers when new ideas and methods can be inculcated. In many areas, however, sawmillers have organized themselves voluntarily into groups to help the spread of efficient techniques.

The Forestry Agency and the National Federation of Lumbermen's Associations hold a national sawmill production contest once a year in Tokyo. Representative teams from each prefecture compete in the operation of circular saws and band saws. Techniques, operational efficiency, quality of sawnwood, and conversion rate have to be demonstrated before experienced judges.

The contest is taken very seriously and without doubt contributes to improved sawmill production.

Mexico

• Interest in forestry has been making remarkable progress in recent years as shown by numerous publications by the Mexican Forest Service and by well known individuals. It will be recalled that *Los Recursos Naturales de México* (1955) by E. Beltrán, now Under-Secretary of Forest Resources, was the first evaluation of past work published in Mexico, and it still serves as a guide for future work. More recently, M. Hinojosa Ortiz, former Under-Secretary of Forest Resources, has published a book *Los Bosques de México*[3] where he handles with courage the existing problems and points up earlier faults. In it he stresses the need for more emphasis to be put on training, research, and rational management.

Several foresters have compiled the *Monografía Forestal del Estado de Michoacán* recommending silvicultural, management and protection practices to bring the pine stands up to higher productivity. This is of particular interest because of the plans which FAO hopes to carry through for a study tour on Latin-American conifers for countries interested in the introduction of these potentially important species in their national planting programs.

[3] HINOJOSA ORTIZ, MANUEL. *Los Bosques de México*, Mexico D.F., Instituto Mexicano de Investigaciones Economicas, 1958.

CHINA: *The series of stamps below, the first forestry set to appear in China, was issued at the end of 1957. They all have the same value (8 yen) but have different designs serving to highlight the campaign against forest fires and the campaign to afforest bare and denuded watersheds.*

INDIA: *This photograph showing a windbreak of* Acacia melanoxylon *and* Callitris rhomboidea *around a tea garden, is taken from a useful bulletin on* Wind Erosion, Windbreaks and Shelterbelts (*Farm Bulletin No. 46*) *issued by the Indian Council of Agricultural Research, New Delhi. The bulletin is one of a series issued on agricultural and animal husbandry subjects, and was written by the Chief Conservator of Forests at Himachal Pradesh, and a member of the Soil Conservation Research, Demonstration and Training Centre, Chandigarh.*

Eucalypts are also receiving more attention in Mexico: many plantations have been started on a commercial basis for raw material supply for the manufacture of wood particle boards.

Experience with eucalypts in Latin America will be brought to the fore at the second World Eucalyptus Conference which FAO expects to organize in Brazil in 1961. This will mark another phase in FAO's continuing program to promote interest in eucalypts that started with the Australian Study Tour of 1952 and was highlighted again by the World Eucalyptus Conference held at Rome in 1957.

Sudan

• An FAO technical assistance officer, D. A. Francis, writing of air surveys made early this year in Equatoria by the Survey Department's aircraft, reports that despite often adverse weather conditions it was possible to photograph the priority areas previously selected towards the Uganda border. By alternating the aircrews, the aircraft flew practically every day. The crews worked on the principle of going to have a look at the area from above and not relying on local weather reports. Often an area might be clear for about an hour between 8 a.m. and 9 a.m. but not otherwise, and advantage could immediately be taken to take photographs.

In the Imatongs mountains, the aerial view served to emphasize what had already been appreciated on the ground, namely the severe topography even in the upper regions. There is considerable dense forest but much of it is on steep slopes and in deeply dissected areas where extraction will be difficult.

In discussing the photographic and forest inventory program with government officials, the way in which aerial photography could assist in selecting areas for forest reservation has been stressed. A round table conference of all the interested parties (agriculture, land use, veterinary and game preservation) under an independent Chairman has been suggested to deal with the arguments so often put forward that the forests contain land suitable for agriculture and should not therefore be reserved. It has to be pointed out that there is probably not one single forest reserve in the whole of Africa in which some area suitable for an agricultural crop could not be found.

Field survey work is not without its excitements in the south of the Sudan. Herds of elephant and buffalo are met crossing the traces which have been cut through the forest. The technical assistance officer writes: "The ultimate was reached in a game reserve last Sunday when an accompanying game scout (one is only allowed in on foot and with a game scout) proceeded effectively to drive off an inquisitive rhinoceros by throwing stones at it."

Sweden

• With the world's growing population, interest is increasingly focused on the resources that in the near or more distant future will be available for this population. One of the most important resources is the world's forest area.

A comprehensive study entitled *World Timber, Trends and Prospects*[4] has been published in Sweden, and it attempts a forecast of future supply and demand of timber for various purposes on a world-wide scale. It is founded on a thorough analysis of trends in production and consumption and in trade in forest products and draws on the author's long acquaintance with the principal forest regions and markets for forest products.

The author, Professor Thorsten Streyffert, rector (dean) of the Royal School of Forestry at Stockholm, has of course an international reputation in forestry, and his book demands close study. FAO has often benefited from his great experience and knowledge, and his findings in this book will be of considerable value in relation to the phased series of detailed regional "timber trends studies" on which FAO is presently engaged and which it hopes to bring to a conclusion in a few years with a general world picture.

• A commentary on the paper on the use of insecticides appearing earlier in this issue, is expressed by news from Sweden. New methods for fighting insects have to be resorted to as breeds resistant to DDT, hexachlorine and other chemical agents develop. In agricultural areas, where these chemicals have been used in abundance, the situation is already alarming and, when forest insects begin to become resistant, great danger lies ahead.

Swedish scientists have engaged a new ally, small pathogen micro-organisms, such as viruses, bacteria and fungi. The Swedish Forest Research Institute has received a substantial grant from the Swedish Wallenberg Foundation to speed up research. The aim is to develop viruses which attack one type of insect only, so that a campaign can be launched

[4] STREYFFERT THORSTEN, *World Timber, Trends and Prospects*, Royal School of Forestry, Stockholm. pp. 246, Sw.kr. 40. 1957.

against whichever kind is most injurious at a given time and place. The goal is developing virus types that are 90 to 95 percent active. Extremely small quantities of virus are required to immunize large districts. The virus content of five infected insects is said to be enough for spraying five acres.

Switzerland

• A collection of technical papers contributed by friends, colleagues and co-workers drawn from several countries of Europe, from the United States of America, South Africa and Indonesia, are contained in *Festschrift zum siebzigsten Geburtstag* published as a tribute of esteem to mark the 70th birthday of Dr. Hans Burger, former Director of the Swiss Federal Forest Research Institute and ex-President of the International Union of Forest Research Organizations.

The contributions range from general papers to detailed reports of the results of research on specific facets of the problem of the interrelationship of forest cover with water and soil. This is a subject which has perhaps been closest to Dr. Burger's heart, for, although his interests in forest research are wide, the water regime aspects of forest influences have long been his speciality. He undertook exhaustive experiments in soil physics, measurement of silt-carrying capacity, and critical examination of methods of obtaining climatic data. He recognized the limited validity of certain research results and caused parallel experiments to be carried out under completely different conditions.

Shortly before Dr. Burger reached the age of retirement, two new gauging stations were inaugurated in the Flysch district of the canton of Fribourg. These important research stations, established to determine the relationship between afforestation and streamflow, can be regarded as practical achievements crowning Burger's activities in this field of research.

United Kingdom

• The first mill in the world to employ a continuous pulping process using a variety of hardwoods, continues to operate successfully. Opened in October 1958 with an initial production of 50 tons of bleached pulp daily, the mill employs the neutral sodium sulphite process and is automatic in operation, control being exercised by one man from a central instrument panel.

The Forestry Commission took the initiative in arranging a joint investigation with the industrial group concerned to discover whether hardwood thinnings could be used to produce wood pulp for paper making. The result of this investigation proved that sufficient wood was available and that a speciality bleached pulp, to blend with other raw materials, could be produced.

The pulpwood used at the mill must conform to a set specification otherwise it cannot be barked or chipped successfully. In the main, sound hardwood of at least 13 different species can be used, provided billets are cut into 4-foot lengths, are between 3 ½ inches and 12 inches in diameter, and are reasonably straight and not forked.

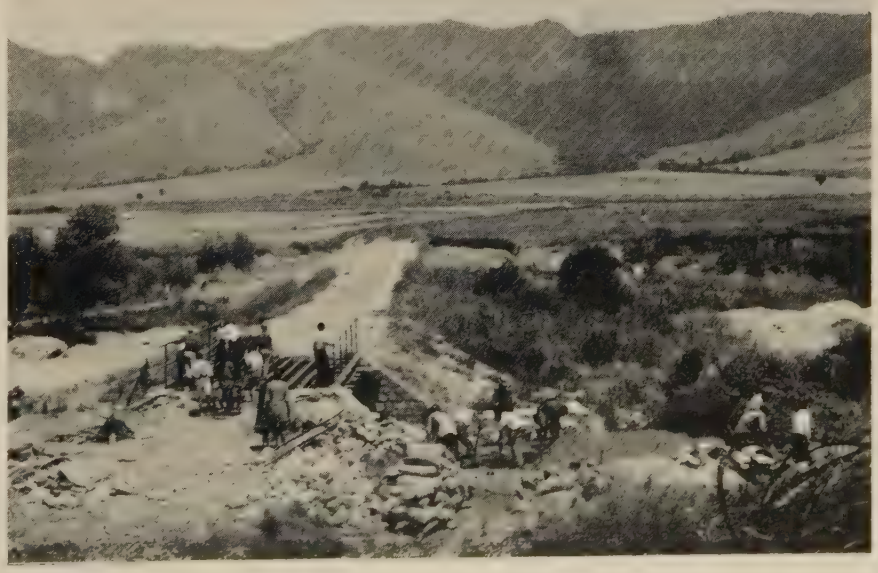
The species of trees most suitable for the production of bleached hardwood pulp are oak, ash, birch, beech, alder, elm, sweet chestnut, sycamore, lime, poplar, willow, hazel and maple.

• The preface to *Forest Machinery*,[5] recently published, explains that mechanization in the forest has reached a new level of importance which is not yet catered for in the technical literature on forestry. This compact book is designed to help fill the gap. It confines itself to a general description of the varied machines and equipment used in all branches of forestry and does not attempt to give constructional details nor to cover all models and types.

After dealing with the economic considerations determining the adoption of mechanization, the authors discuss the principles governing the application and operation of machinery, and then go on to deal in turn with nursery equipment, machines for land preparation and forest establishment, road construction plant, equipment for felling and rough conversion, extraction, ancillary machinery, and equipment used in forest protection.

[5] HUGGARD, E.R. and OWEN, T.H. *Forest Machinery*, 192 pp. illus., A and C. Black Ltd., London, 24s. 1959.

IRAN: *A note was included in* Unasylva *Volume 12, Number 3 on the Lowe demonstration forest area in north Iran. Mr. H. A. M. Gläser, who has been technical assistance officer in charge of the project, sends these further photographs of (right) a compartment where regeneration fellings are being carried out, and (below) construction of a bridge for the access road over a torrent-type stream.*



THREE STAMPS OF INTEREST TO FORESTERS: *The Federal Republic of Germany issue (top left) for the Saarland draws attention to a "Prevent Forest Fires" campaign. The Autonomous Republic of Togo issued a first pictorial set of 18 values at the end of 1957 to celebrate its independence. The design (top right) shows a forest of African "teak"* (Chlorophora excelsa). *The Sarawak stamp (center) depicts ramin logs being manhandled out of the forest to floating point.*

Union of South Africa

• Dr. W. E. Hiley has performed a worthwhile service to foresters everywhere in recording his observations [6] on the reputedly unorthodox forest plantation practices followed in the Union of South Africa.

The author explains the "agricultural approach to forestry" followed by the South African pioneer foresters in their huge task of establishing and managing extensive plantations of exotic species. This approach has led to "numerical thinning" as a means of greatly reducing the cost of growing timber trees. The author feels that these methods should find application or at least be adaptable to forestry elsewhere: he points out that even those South African foresters who were at first sceptical are enthusiastic about the results so far.

Readers will be interested to follow Dr. I. J. Craib's prescriptions for spacing and thinning for various species. The fact that both private and public investments have been based on such prescriptions suggests that a careful look should be taken at the measurements accumulating in the C.C.T. (Correlated Curve Trend) plots of various densities and ages for the more important exotic species. Unfortunately, in his small volume, the author has only been able to give a brief but tantalizing account of such measurements.

It is hoped that subsequent technical papers will elaborate the results, and in the meantime, foresters will watch with keen interest the financial results of investments of such organizations as South African Forest Investments Ltd., Peak Timbers Ltd., and the Usutu Project of the Colonial Development Corporation which are using the new methods with slight modifications as they go along.

United States of America

• Professor Worrell explains in his Preface to the *Economics of American Forestry* [7] that his book is written primarily as a text for a college course in the economics of forestry, adding: "Naturally I will be pleased if practicing foresters find it helpful in their everyday encounters with economic realities." He need have no fears: his book is clearly destined to become a standard text.

The title reflects both the approach and the scope of the book. The term, economics of forestry, is preferred to forest economics because "the principles and theories which have been developed for economics apply to forestry just as they do to any other human endeavor... The truth is that a forest economist must first of all be an economist. And economics is economics whether its subject is forestry or retail trade or automobile manufacture." What follows, therefore, is a course in economics, elementary for the most part, in which all the illustrations are drawn from forestry and in which those sections presenting particular problems for or of special importance to the forester are given greater emphasis or treated at greater length. Thus the longest chapters are those concerned with production economics, growing forest products, forest land economics and marketing forest products.

The sequence is logical and well adapted to the student's requirements. The frame of discussion is set by introductory chapters dealing with basic economic relationships affecting forestry, and forestry in a free enterprise economy. Next follows a discussion of the consumption of forest products and services, and consumer demand for forest products. The supply of forest products and services leads on to production economics, at which point the processing of forest products and the demand for wood as a producers' good are dealt with before proceeding to chapters on growing and harvesting. Chapters on the factors of production — land, capital and labor — are followed by discussion of forest products marketing and prices.

Non-crop values of the forest are accorded their due importance and squarely presented, along with forest products, in the main chapters on consumption and supply. However, to avoid any break in the flow of the argument, detailed discussion is deferred to a later chapter, "Unpriced Forest Products and Services," preceded by one entitled "Social and Private Costs and Benefits in Forestry." The concluding chapters deal with the future demand for forest products and services, ownership of forestry enterprises, and the role of government. Throughout the book the examples are well chosen and the text tables and figures clear and comprehensible.

The book is illumined throughout by the author's strong sense of the forest economist's responsibilities, and his flair for presenting succintly areas of investigation which should

[6] HYLEY, W.E. *Conifers: South African Methods of Cultivation*, 123 pp. illus., Faber and Faber, London, 21s, 1959.

[7] WORRELL, A.C. 1959. *Economics of American Forestry*, John Wiley and Sons, Inc., New York, Chapman and Hall, Ltd., London, $9.75.

command attention. Two examples will suffice:

"One important current function of economic analysis is to indicate the kinds of data which silviculturists and others should develop as a step toward economic decisions by forest owners." (p. 116).

"A risk is an outcome whose probability of occurrence can be established in a quantitative manner. ... One of the fertile fields for development in the economics of forestry is the reduction of some of the many production uncertainties to production risks." (p. 192/195).

All the illustrative material cited in the book is taken from American experience, while emphasis is naturally given to those problems which loom largest in North America. This does not limit the usefulness of the work to teachers and students — and practicing foresters — outside North America, because the author has carefully subordinated the descriptive material to the analytical approach. Practicing foresters will be happy to know that the author's clear and convincing style has produced that rarity, a book on economics which it is a pleasure to read and which engages the attention from first to last.

• Written as a textbook for a one semester course in conservation at the lower division college level, the appearance of *Environmental Conservation*,[8] although it tells nothing new, is both welcome and timely. It fills the need for a teaching aid on the subject, restricted though its lessons are to conditions in the United States. The aim is to arouse "a sense of shame in the proprietorship of a sick landscape."

The author traces man's record on the earth to the present rise of industrial civilization which equips him with the power to shape almost any environment into a landscape of his own choosing, and to channel its materials into an industrial network which can create for him a high degree of security and material enrichment. But, with these new powers and techniques has disappeared the opportunity for long periods of adjustment to nature. Unless man is made aware of the dangers of these great powers, he remains in peril.

The second portion of the book is devoted to a study of each of the basic natural resources of soil, water, forests, range, and wildlife; their use or misuse in the past; and the measures adopted or recommended for their conservation and long-term productivity in the interests of man.

The real significance of the course — and of the book — comes in the short third portion of the publication in which respect for the traditional separate consideration of conservation according to individual resources is discarded for the all-embracing environmental approach. The "multiple use" ideal for management of national forests expresses this approach, and the remaking of the Tennessee River Valley by the TVA is another example. Both involve the pooling of the technical knowledge and viewpoints of as wide a range of interests as possible.

• Highlights of program goals for the national forests over the next 10-15 years, drawn from a report transmitted to Congress by the Secretary of Agriculture, are:

More and better water: Step up watershed management and protection to increase the quantity and improve the quality of water yields.

More wood: Increase annual harvest by 7 to 11 billion board feet (31.5 to 50 million cubic meters) through intensified sustained-yield management of present timber stands, growing more and better trees, reducing disease, insect, and fire losses, and improving utilization.

More recreation: Meet the needs of an expected 130 million annual visits by 1969, almost double the 68.5 million recreation visits in 1958.

Better hunting and fishing: Accommodate the increasing number of people seeking outdoor sport on the streams, lakes, and trails of the national forests.

Better range and grazing: Improve the range resources to achieve sustained high-level forage production and better watershed conditions through intensified management, better range practices, and more balanced use. Make lands available for grazing under conditions that promote individual and community stability.

Supporting activities include intensified protection, an expanded road system, boundary adjustments and ownership consolidation, providing essential structures and equipment, and accelerated research.

THE SACRED AND PROFANE: *A bizarre montage made from natural tree roots.* Courtesy, Foto-Dengler, Bad Wurzach, Germany

[8] DASMANN, RAYMOND F. 1959. *Environmental Conservation*, John Wiley and Sons, Inc., New York, 307 pp. $6.50.

moved him to speak out openly against the Bishop of Florence himself. Beaten up and wounded by the Bishop's armed men, he nevertheless managed to take the road to the mountains, resolute in his determination to carry on with his fight against a man who was causing such great harm to the Church. Wandering on, he arrived during a storm in a part of the country called Acquabella late one afternoon in March of the year 1036. He sought cover as best he could under a large beech tree which at that time of the year was without leaves. On waking up the next morning, John was surprised to find that his cloak was completely dry. Looking up above him, he saw with amazement that during the night the beech tree had grown new leaves and that its branches had bent down forming a canopy over him, so sheltering him from the rain which had been falling continuously throughout the whole night. This he took as a sign that God's will for him was that he should remain there among the trees and mountains. And thus he stayed on until almost the day of his death 37 years later at the age of 78. (It was a little more than a hundred years later, in 1193, that he was canonized by Pope Celestine III).

Not long after the miracle of the beech tree, a few other hermits joined him and John Gualberto built cells for them and a chapel in wood. Little by little his fame as a holy monk spread throughout the whole of Tuscany and the number of those coming to join him continued to grow. Already by the year 1040 the Community had its own Rule, which John wrote, basing it on that of St. Benedict but making it more austere. The Acquabella region later became known as Vallombrosa so that the Monastic Order founded by John there and confirmed by Pope Victor II in 1055, took the name of the Vallumbrosan Order. Even during its founder's lifetime, the Order spread throughout Tuscany, Romagna and Lombardy. Later it extended even further into many other regions, reaching as far as Sicily and France.

The Saint's work and struggle for the raising of moral standards was accompanied by efforts in many other directions as well, since St. Benedict's motto "Work and Pray" was also his. As if he saw a connection between the improvement of morals and that of the land, he set an example by working with his own hands to provide for the daily needs of the community and to reclaim and bring into a better state the area immediately surrounding his first monastic foundation — this in an age when work on the land was considered good only for serfs. He devoted part of his time to silviculture even in his old age and thus it was that he was successful in improving the Vallombrosan region which in those days was completely wild. The Saint and his monks had to use primitive methods adapted to the few tools they had. The stagnant waters were drained by ditches and the woodlands in the immediate vicinity of the monastery were cleared either for firewood or to ensure that no wild beasts or poisonous snakes could lie hid too close to the cells. After that work the new community passed on to the task of restocking the surrounding forests with new trees and to planting up empty spaces. The natural regeneration they encouraged by breaking up the soil round the trees with rakes so that the falling seeds would land in a soil where they would germinate; or else, at the right time of the year, they got pigs to break up the earth by grubbing around the trees. As for the reforestation which John carried out on slopes to prevent soil erosion caused by torrents and streams, he varied the methods according to the size of the area to be tackled. If small, he planted wildings obtained from adjacent woods or grown from seed in the small nursery adjoining the monastery. If the area were large, he established a properly stocked plantation there, or alternatively resowed the whole plot by first hoeing and plowing the soil, then carefully scattering the seed and finally earthing it over.

In the succeeding centuries the Vallumbrosan monks continued his work, and it was better organized on an ever greater scale. Their methods improved as new techniques were evolved. Just as Monte Cassino was later looked upon as the cradle of agriculture, so Vallombrosa laid the foundation of the scientific approach to silviculture. Vallombrosa became a small model oasis and all, both monks and mountain people, following the Saint's example, did their best to extend forest plantations into the surrounding districts as well. Many Vallumbrosans, in keeping with the tradition started by their founder, as well as seeing to the care of their forests, devoted themselves to the scientific pursuit of botany and silviculture at a time when this was an unknown study in Italy, and with such success that the most famous universities, Italian and foreign, used often to apply to the Vallumbrosan Congregation to be certain of having teachers of repute.

La Festa della Montagna for Central Italy took place this year precisely on 12 July, the Feast day of John Gualberto, in the very heart of the famous silver fir forest of Vallombrosa. The delegates to the Tenth Session of FAO's European Forestry Commission attended this festival and had the opportunity to judge for themselves just how fruitful had been the care of this area over nearly 1,000 years.

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